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Damages by floating ice are being made good on this gas-lighted buoy that is lashed alongside a tender of the U. S. Lighthouse Service

NATURE'S SUBMARINES [See page 280]

Furnaces for Munitions*

Principles of Design

NEVER at any previous period has there been so urgent a demand on the manufacturers of furnaces for heating metals as has been witnessed since the beginning of the war. This is the immediate result of the pressing need for shells and other munitions of war. The movement, however, had antedated the war by some years and arose out of recognition of the fact that the heat treatment of steels must, if their highest properties are to be secured, and with uniform results, be carried out by very precise methods possible only in furnaces designed to permit of exact regulation and fine measurement of temperatures.

The smith, the boiler-maker, and the plater have always practised heat treatment on the loose method of trial and error, of experiment and experience, which though of much value lacks the safe basis of an exact knowledge of the essential facts underlying the practice. Only those furnaces and methods are suitable for the exact heat treatment of steels which provide for the prevention of oxidation, the precise regulation of temperature in continuous working, and the measurement of its variations within two or three degrees, with arrangements when desired for obtaining a continuous record of temperature variations for inspection and reference. The results that are regularly obtained are marvelous, in view of the very high temperatures involved, and represent one phase of present-day requirements for standardization, specialization, and precision in all departments of engineering work. Yet they are now secured in many different designs of furnaces, varying widely in their details, such as in the methods adopted for heating and the control over temperature, in their dimensions and shapes, and in their systems of handling the work.

The employment of high-speed steels has been one potent agency in the employment and development of these precision furnaces. Another has been the increasing practice of using hardened or toughened parts, or those which combine a toughened interior with a glass-hard surface, which are common in some portions of machine tools, and in automobile work, as gears, cams, shafts, spindles, and so on. An important collateral fact has been the enormous multiplication of the alloy steels, which owe their special value to elements other than carbon. These are even more sensitive and responsive to heat treatment than the carbon steels, and without such treatment the characteristics which render them of especial value are not developed fully.

NEED FOR TEMPERATURE CONTROL

If precise results are to be secured the critical temperatures or change points must be defined within a very narrow range. The critical temperatures—that of calescence, C, after passing which a steel will harden, and that of re-calescence, R, below which it will not harden—are each set within a limit of one or two degrees for any one grade of steel, though a long range separates the two. If a steel has not been heated up to or beyond C it will not harden. If it has been heated beyond C (short of burning) and is let down or allowed to cool, it will harden at any stage not below R. At the critical points a pause occurs in the temperature movements. In the ascending scale, at the point of calescence, heat is absorbed in consequence of the diffusion of iron and carbon to form pearlitic steel, and thus the temperature remains stationary for a brief period. On the descending scale, at the point of re-calescence an evolution of heat takes place, and then a sudden rise in the temperature occurs. These facts sufficiently explain why means of temperature measurement should be employed capable of indicating the temperatures of the critical points, and why the furnace temperatures should be capable of equally exact control.

CHARACTERISTICS OF FURNACES

When coke or coal was used for heating, as was the general practice only a few years ago, a reasonably approximate regulation of the temperatures was not practicable, and they would fluctuate with the character of the firing and the regulation of the damper. Even then the temperature in different parts of a large reverberatory furnace would vary by perhaps as much as 40° or 50° F., an extent of range utterly irreconcilable with the correct treatment of any steel, and especially the complicated alloy steels. The apparently contradictory results which puzzled steel users in the past are largely attributable to ignorance of the meaning of critical temperatures, and of the necessity of heat treatment. The use of coke, with which it is not possible to secure equal firing, is also wasteful, because much heat goes up the chimney, and time is occupied in stoking and cleaning. The sulphur and other elements which mix with the products of combustion are liable to injure the steel. Recent improvements, therefore, have advanced along two lines; one is the substitution of gas and oil fuel, and the other the measured regulation of supplies of fuel and air. Behind the varied details of the construction of furnaces these improvements find general application. Different, though equally efficient, methods depend on the use of electric furnaces and lead baths, and of salt bath furnaces, with preparations of salts of sodium, potassium, or barium, which fuse at some exact and known temperature.

GAS AND OIL

Many furnaces are built to utilize town's gas, producer gas, or oil. The action of each may be quickened with blast, or gas may be used with natural draught, each system only requiring differences in the burners. In many cases pre-heating is adopted, or the waste gases are utilized in some way. Burners are constructed with adjustments for gas and air supply, so that when they are once set the volume supplied remains constant, and no alteration of pressure can take place. Oil burners are usually made for creosote or other crude oil, or petroleum. When furnaces are large it is better to employ several small burners than one or two large ones. The regulation of temperature is often made automatic in character. The gas or oil runs at full pressure until the temperature for which the adjustment has been made is reached, when a regulator which operates thermostatically cuts off the supply automatically. When the temperature falls too low the regulator allows a fuller supply of gas or oil to flow.

TYPICAL DESIGNS

Although in general the furnaces used for munition work are built on standard patterns, so far as methods of construction and principles and systems of operation are concerned, yet many special details are introduced in order to adapt them to their particular duties, especially with the object of facilitating the handling of large numbers of pieces.

For heating shell billets preparatory to piercing and drawing, one of the reverberatory furnaces of large capacity is used. These are similar to those used by platers and boilermakers, but instead of being required to receive large plates and long rolled sections, big batches of small pieces have to be treated. The temperature also must be raised gradually to permit the heat to penetrate uniformly, otherwise the steel would be liable to crack, or internal strains would be set up, or variable degrees of hardness would be developed. Temperatures of from 1,200° to 1,300° C. are suitable. Two large examples of this type, installed by the Dowson and Mason Gas Plant Company, have hearths measuring 16 ft. in length, and heat sixty billets an hour each, for 4.5 in. high explosive shells. The furnaces are gas-fired, and have inclined hearths. Sometimes small billets are carried through a long furnace by an endless chain conveyor; they are loaded at one end of the conveyor outside the furnace, and removed at the other. The rate of travel and the temperature are both capable of regulation. The furnace doors, double in the larger sizes, are opened and closed vertically, and are counterbalanced. One of the Lord furnaces, which has a bed 12 ft. long by 4 ft. 6 in. wide, has a crown divided into three arches, which is favorable to uniform heating. The shells are inserted and withdrawn through three openings at one side.

In one type of the August muffle furnaces, a principle of action has been adopted that has been employed in rivet-heating furnaces—that of automatic feeding by gravity from colder to hotter chambers. After the first filling of the furnace the shells are laid singly on a holder provided on a top door, and when a lower door is opened and a heated shell taken out, a cold shell enters the furnace from above. The gravity movements take place along the upper chamber, the bottom of which slopes away from the door towards the back. The shells roll down into the lower chamber, the floor of which is inclined towards the front for a portion of the way, and are disposed horizontally to the discharging door at the front. Eighty billets measuring 7 in. by 4 in. can be accommodated in the furnace at one time, and about a hundred can be heated in an hour.

Richmond furnaces, which are largely used for munition work, are either of muffle or of oven design, the latter being suitable when the furnace gases will not injure the work. The principle of the first is that of the Bunsen burner. Gas enters the chamber from the burner, which emits separate tongues of elongated flame. The air is drawn in at various points so distributed as to assist the up-draught from the burner, and becoming heated before mingling with the Bunsen flame. In twin-oven furnaces, the heat from the lower or working oven passes into the upper one, in which articles are gradually pre-heated before being put into the lower one.

NOSING FURNACES

For heating shells for bottling, that is, for closing-in the nose to receive the fuse after the interior has been bored, special designs of furnaces are used to localize the heat round the nose while the body of the shell is outside the furnace. Usually holes in the sides receive that portion of the shell which has to be heated, the axis lying horizontally. The furnaces are frequently double-sided to receive shells through opposite faces. The weight of the overhanging portion of the shell is taken on rollers or on the edge of a sheet metal support. Gas is used for heating, with an air blast. In one of the Allday furnaces the burners blow into the chamber at a tangent and the gases whirl round the work. Many circular furnaces are made for this work, having holes distributed round the periphery. A Monometer furnace has two tiers of holes, and is fired by a mixture of oil and air, each supply being capable of regulation. One of the Richmond gas furnaces, with eight holes, is rotated like a turret with worm gear, the rate of rotation being regulated by a four-speed belt pulley; 120 3.3 in shells can be heated in an hour. In the Wright rotating furnace the articles to be heated are carried vertically in pockets in a table of fire-brick, which makes one revolution in five minutes. In this period the shell becomes red hot at the end. It then drops into a receptacle below, from which it is picked up and put into the nosing dies. Gas and air burners are used to heat the furnace, each being under separate control. The same design is employed for annealing brass cartridge cases, and for heating the Muntz metal rings for shell caps which have to be pressed into shape.

CARTRIDGE CASES

Cartridge cases have to be annealed after each main operation of drawing, and since they are treated in big batches, large furnaces of the reverberatory type are the most suitable, being large enough to hold some hundreds of cases at one time. These are inserted in batches of from 50 to 150, according to size, on a tray, and several trays are in the furnace at one time. Every six or eight minutes a tray full of cases is drawn out and another inserted. About 35 minutes are required for heating a batch. Temperature is regulated by pyrometers.

SHELL-DRYING

The war has created a demand for large numbers of shell-drying ovens to dry the lacquer which is brushed on the interior of the shell cases after they leave the machinists. The drying is done at a temperature of 350° F. The shells are placed on shelves arranged on a truck. The shelves may either be fixed to take one size only, or be movable to accommodate different sizes, and the truck is run on rails within an oven fitted with gas burners on opposite faces. Regulation of temperature is provided automatically by a thermostat. The oven walls are double, and are packed with silicate cotton or other non-conducting material.

* London Times Engineering Supplement.

Sulphur and the Spontaneous Combustion of Coal

IT has been shown by experiment that the sulphur contained in coal in the form of pyrites is not the chief source of spontaneous combustion, as was formerly supposed, but the oxidation of the sulphur in the coal may assist in breaking up the lumps of coal, and thus may increase the amount of fine coal which is particularly liable to rapid oxidation. Even this opinion is not unanimously endorsed. In spite of experimental data showing that sulphur is not the determining element in spontaneous combustion, the opinion is widespread that, if possible, it is well for storage purposes to choose a coal with a low sulphur content.—*The Engineer.*

Testing a Light Filter*

It is customary to say that the effect of the screen varies according to the plate with which it is to be used, and, in the strictest sense this is so. But in actual practice, we need not take this into account, unless some plates of a peculiar color-sensitiveness are in use, plates which would only be obtained to order and for a special purpose.

As far as the screen is concerned, we may divide all orthochromatic plates into two groups, the ordinary orthochromatic kind, in which are included the self-screen on non-filter varieties, and the panchromatic. It is hardly necessary to point out that the screen would not be used at all with plates which are not color-sensitive. When once we have found out the difference of exposure which it requires with any plates of one group, we shall not be appreciably wrong if we treat that result as being good for any plates in that group.

The actual increase is slightly less with "self-screen" plates than with those which have no screen incorporated with the emulsion, but it is not large enough to need to be taken into consideration in practical work. With panchromatic plates, the effect of any yellow screen in prolonging exposure is always very markedly less than it is with orthochromatic plates of any other kind.

To ascertain just what the increase is, we must make comparative exposures on the plates in general use, with and without the screen: and in order to make a single experiment tell us what we wish to know, we must see that on the plate exposed through the screen we have a varied series of exposures to compare with the correct exposure without a screen.

As the screen has a visibly yellow tint, we know that it must increase the exposure to some extent; and unless it is a very deep shade indeed, we shall be fairly safe in assuming that the increase will not be more than ten times. We may base our test, therefore, on the supposition that with the screen the exposure must be from two to ten times what is required without it. So that if we decide on the correct exposure without it, our trial exposures with it may be, say, 2, 4, 6, and 10 times that exposure. Amongst these four we are pretty sure to get a clear indication of what is required.

On the whole, it is better to avoid a subject which itself contains any strong colors; as the different renderings with and without the screen may make it difficult to draw any correct conclusion. If a subject is being arranged for the test, nothing is better than a cylinder of card, round which has been wrapped a newspaper, or even a sheet of white paper. The cylinder is laid on its side on a table covered with a black cloth. Such a subject is easily arranged. It is focussed on the screen, the plate being used the horizontal way. This then gives us a subject which has very marked light and shade, and is uniform from one end of the plate to the other. This is a great point in the comparative test.

The exposures must be made in good daylight; so the increased exposure which a screen necessitates varies according to the nature of the light. By any form of artificial light of the domestic kind, the increase would be much less than by daylight: and for all the ordinary purposes of amateur photography, it is the daylight result which we wish to know. If for any reason we wish to use the color screen by artificial light, then separate tests must be made by the particular light to be used.

Having set up our subject and focussed it, we proceed to ascertain the correct exposure without a screen for the plate we are using. It will be well to use the smallest stop in the lens, as there is no fear of such a subject moving, and it is best to make the exposure required sufficiently long to allow them to be timed accurately by hand. If the photographer is in the habit of using an exposure meter, he will be able to ascertain this without any trouble. If he has not, then it would certainly be best to give up the first plate to a series of exposures, and to develop it before making the test: so that he may know just what it would be. If this should mean that the preliminary trial must be made a day or more before the real test, this need not be regarded as an insuperable difficulty, provided the light on the two occasions seems to be much about the same, as it would be at the same time of day and with similar weather.

Having decided what is the correct exposure without the screen, we may proceed to give it. As a help in comparing the results, though, we may as well give, say, three exposures to the plate. Thus, if the correct exposure is three seconds, we may give a second and a half with the shutter of the dark slide drawn right out. Then, pushing it a third of the way in, we give another second and a half, making three seconds in all. Pushing it two-thirds in, we give another three seconds. So that the negative will be in three different sections, which have received one and a half, three, and six seconds respectively. This may help us when we come to compare the negatives, although in this case it is not actually necessary to give more than the single exposure to the plate, if we are sure what the correct exposure is.

The screen is then put on the lens and preparations made for exposing a second plate. The least increase we may assume to be twice, so that the first section of this will receive six seconds exposure. The shutter being pushed in a little way, we give another six seconds; then a little more and a third six, and the final strip receives twelve seconds more. So that the exposures on this plate will be six, twelve, eighteen, and thirty seconds, which are respectively two, four, six, and ten times the correct exposure without any screen at all.

In order that the results may not be confused by any difference in the degree of development, we put the two plates side by side in the same dish, and develop them together. It is quite possible to form a very good idea of the increase required, merely by noting the way in which the different strips appear under the influence of the developer: but we must not forget that we are dealing with yellow-sensitive plates, and any more exposure to the dark room light than is absolutely necessary is a thing to be avoided. It is better on the whole to curb our impatience, and to keep the dish covered as much as possible. When the correctly exposed strip on the unscreened exposure seems to be about correctly developed, the plates should be fixed, washed, and dried. They are then ready to be compared.

It will almost certainly happen that, when they are put side by side, one exposure on the one will be found practically identical in depth with that on the other: and when once this has been found, it only remains to note what time was given to each to learn the effect which the screen is exercising. For example, we may find that the eighteen seconds with the screen is identical with the three seconds without it; when it is evident that the screen increases the exposure six times. If the eighteen seems a little too much, while the twelve is a little too little, it may be taken to be a five times screen, and so on.

In making the comparison, an endeavor should be made to compare with the correctly exposed or central section of the negative made without the screen: as less dependence is to be placed on trials between incorrectly exposed sections. We must be careful also to compare depth of image—printing character—and not that very illusive and misleading quality, detail in the shadows.

Should the range of increased exposures given to the plate exposed through the screen not be sufficiently extended to cover the actual increase which it entails; then the fact that on the unscreened negative we have a strip which has received one half the correct exposure may be helpful. For instance, the strip which had ten times the normal, may only just match the strip on the unscreened negative which had half the normal, from which we may conclude that the screen calls for a twenty times increase. In such a case, however, a second series of tests should be made to confirm this, and to get a more accurate reading. As a matter of fact, commercial screens calling for more than ten times increase are not very often to be met with, but with home-made color-screens it is not unlikely that such a depth of tint may be obtained.

* *The Amateur Photographer and Photography.*

Damascene Steel

Damascene or Damascus steel made its appearance in western Europe during the Middle Ages. It was manufactured in India, and the origin of the process may be traced back many centuries B. C. The same kind of steel had previously been introduced into Russia, where it was known as "poulad" or "bulat." The external characteristic of this steel was its patterned surface-watering or "jauher" (Persian), which gave rise to the name "poulad jauherder." It was imported into Russia through Persia and the Caucasus, and into western Europe through Syria and Palestine.

A most interesting and important study of this material was presented by Col. N. T. Belaiew at the spring meeting of the Iron and Steel Institute. According to his researches, there were three principal methods of producing it:—

(1) The old Indian, by which crucible steel was made by melting pure ore with the best kind of charcoal; (2) the Persian, in which case pure soft iron and graphite were the ingredients; and (3) a particular heat treatment which was in the nature of a prolonged tempering.

The greatest care was taken in regard to the temperature and duration of the melting process, since it was known that the best "watering" could be obtained only with alloys which were kept molten for a long time and afterwards very gradually cooled. The fluid alloy was allowed to freeze in the crucible, and removed only when cold in the form of a cake.

These cakes have been described by Travenier and others, and were brought to this country by Scott. Numerous investigations were carried out on them, notably by Stodart and Faraday in England, Réaumur and Bréant in France, and Anossoff in Russia. The last-named was led so early as 1831 to apply the microscope to the study of polished and etched surfaces, not merely of these steels, but also of all his alloys that were intended for industrial applications. He was the first to classify the patterns of damascene blades, and showed that in steels containing the least carbon the watering took the form of parallel stripes, and that as the carbon increased these became wavy, then mottled, and finally passed into vertebræ, which were considered the most perfect form. To this the Persians gave the name "kirk narduban," or "forty steps of Mahomet's ladder."

Col. Belaiew took up the experimental study of these steels at the instigation of Prof. Tchernoff, who, in lecturing at the Michael Artillery Academy, Petrograd, stated that "the best kind of steel ever manufactured was undoubtedly the bulat." He found that the majority of damascene steels contained from 1.1 to 1.8 per cent of carbon. The following is a complete analysis of one of them:—

C	Mn	Si	S	P
1.49	0.08	0.005	0.05	0.10

He then proceeded to reproduce the steels artificially at the Putiloff works, using the Eastern Crucible method (soft iron and graphite), and studied both the primary crystallization (from the melt) and the secondary (from the solid), and showed that the latter differed in its form according to whether the steels were hypo- or hypereutectoid, *i. e.*, $<$ or $>$ p.90 per cent. of carbon. Damascene steels all belong to the latter category. He found that in all cases where the alloys were slowly cooled a remarkably clear primary and secondary crystallization followed. The former consisted of dendrites of austenite of very varying carbon content, the latter of dendrites of cementite which closely followed the orientation of the austenite axes. The higher the carbon the more closely did the primary and secondary crystallizations resemble one another, and a "structure of large crystals" resulted. To understand how, from an alloy with this structure, the beautiful wavy or motley watering of Oriental blades can be obtained, he discusses the life history of a 1.5 per cent. carbon steel from the molten state. Every cake is either cut in two, in which case each half makes the blade of a sabre, or the central part is cut away and the remaining ring is cut through at one place so as to facilitate subsequent working and then drawn into a bar. If the specimen is only drawn lengthwise the "veins" produced are longitudinal and the watering consists of parallel stripes or ronces. But if the forging is executed in two or more directions, then, "according to the skill of the workman and the quality of the damask, all the other shades and graduations—the wavy, the motley, and the 'kirk narduban'—may be obtained." This watering, when examined by the naked eye, represents the macrostructure of the finished article and shows the way in which it has been mechanically treated.

The most remarkable quality of these high-carbon steels is their unusually high degree of malleability. Col. Belaiew shows that while the melting process and the slow rate of cooling are to some extent responsible for this, the real explanation is to be found in the microstructure of the finished article, which reveals the fact that the free cementite (hyper-eutectoid) is no longer present in the sharp, pike-like projections characteristic of the metal in the cake, but is in the form of small, rounded globules resolved at about 50 diameters' magnification, which appear like "milky ways." The main cause of the great malleability of damascene steel is the globulitic microstructure of the cementite produced by forging at a low temperature. This "spheroidizing," which has been studied in other connections by Howe, occurs readily at temperatures rather below Ac_1 (730° C.), and is much facilitated by forging. All the Oriental writers, and especially Anossoff, insist on the importance of not exceeding a red heat during this operation; and the reason for this is now clear.

The Dove of War*

Winged Dispatch Carriers that are Doing Brave Work at the Front

By Lee S. Crandall

At a time when every force for good is rallying to the cause of freedom and justice, we may look for strange things. Men whose interests have centered in business and sports, women whose thoughts have seldom wandered from home and shopping, have risen to undreamed-of heights of sacrifice and devotion. That the dove, the popular symbol of peace itself, should assume the guise of a messenger of Mars, is perhaps the most astounding of all.

As a matter of fact, pigeons and doves are far from being confirmed pacifists. Tradition and the proverb maker have conspired to give them a reputation which mere earthly creatures find difficulty in maintaining. Five minutes spent before an aviary containing doves of assorted species, or in a loft of domestic pigeons, may well result in a lifetime of wondering why the idealized bird which represents this group was chosen as the emblem of peace. The idea has been a great help to cartoonists, but the dove has been placed in a false position. It is true that it has no teeth, claws or wing-spurs, with which to fight, but otherwise it does the best it can. The beak and the wings are the doves' only offensive weapons; but woe betide the columbine trespasser on nesting sites, or the misguided squablet that strays from its parental box.

And so it happens that our great war has given a sturdy race of birds a rare opportunity to show its spirit. News reports teem with the praises of the stout-hearted little bird which already has won itself undying glory on the battlefields of France. What greater praise could be given the erstwhile dove of peace than its new and well-worn title of "war pigeon"?

The pigeon is not entirely new to war. There are hazy references to its use as a messenger by the ancient Egyptians and Persians, when its owners were engaged in warlike as well as peaceful pursuits. The cultivation of the homing instinct, from the time of the Romans down to the present day, is a matter of history. For centuries the development of this faculty was confined to Eastern peoples, and it was not until a considerably later, though indefinite, period that the birds were brought to Western Europe. They then became popular, and were widely kept, particularly in Holland, Belgium and England, where they developed various breeds. Pigeon racing finally became a national sport in Belgium, and we are indebted to that country for the production of the modern homing pigeon.

The blood of the ancient strain gradually became mixed with that of others, so that the direct line of lineage has been lost. Early in the 18th century we find the Belgians in possession of a short-beaked, frill-breasted pigeon, known as the Smerle. This bird probably represents the original Eastern homer with an infusion of the blood of the round-headed African breed, possessed of great intelligence and powers of flight, which was known as the Owl. The Smerle was a fairly efficient flier, and traces of its characters are still to be seen in modern birds.

The English, in the meantime, had produced from their importations various closely related breeds used for homing purposes, chiefly the Dragoon, Horseman and a cross-breed known as the Skinnum. These were large and powerful birds, heavily wattled about the eyes and beak. Some of these birds, probably Dragoons, found their way to Belgium, where they were promptly crossed with the native Smerle. The Cumulet, a white-plumaged bird of tumbler derivation, but noted for high-flying, was also introduced.

From this seeming chaos, after many vicissitudes, the racing Homer, unequalled in speed, endurance and intelligence, finally was evolved. These three characters have remained the great objectives of the breeder, and color, markings and other points commonly sought among domestic pigeons have been ignored. Many derivatives, bred for exhibition points only, have risen to popularity, but the racer, not always uniform in type and color, though never failing in courage and love of home, still remains the pigeon of pigeons.

* From the *N. Y. Zoological Society Bulletin.*

Having proved its value as a flier in Belgium, the newly evolved breed was quickly imported into England, and later was brought to America. The sport of pigeon racing soon became popularized, and its devotees now number thousands. In America hundreds of races are flown yearly, under the auspices of local

A homing pigeon of the Society's Flock

A true racer is always keen and alert, like the thoroughbred it is. This bird has flown 500 miles, and represents the best strains in existence.

clubs and the larger national organizations with which they are affiliated. With the over-running of Belgium by the German hordes of pickers and stealers, the great majority of the famous studs of racing pigeons were seized and sent to Germany. However, the blood of these great strains is widely spread and strongly cherished in England and in America, so that they will not become lost to civilization.

How the war pigeon carries messages

The aluminum capsule is of the type used in active service

Through a confusion of names, which has become widespread, the homing pigeon is almost invariably referred to in news reports as the "carrier." He is a carrier so far as service performed is concerned but, unfortunately, that name was long ago preëmpted by an entirely different bird, closely related to the Dragoon and Horseman, and known as the English Carrier. This pigeon, while perhaps originally used for flying, now is useless for that purpose and is kept for exhibition only. It is a large bird, with extremely long neck and legs, and carries a huge mass of flesh about the eyes and on the beak. This misuse of names has caused much of the credit due the true homer to be given a pigeon which would not home from a distance of a mile.

Many misunderstandings have arisen as to the homing abilities of the war pigeon. Many persons appear to believe that it is merely neccessary to whisper a few directions in the bird's ear, toss it into the air, and watch it strike out for the destination indicated. Other fancies, still wider of the truth, are numerous. There is nothing supernatural about the homer. It simply has a strongly developed love of home, a wonderful sense of direction and the strength and courage to return to its loft when released at a distance.

Sense of direction is strongly developed in most birds. We have only to consider the marvellous migration flights of many species to realize that this is true. In domestic pigeons this sense, doubtless native to the wild Rock Dove from which they are descended, has degenerated through countless generations of life in captivity. Only in the homer has it been retained and magnified by long continued breeding and selection for this point alone.

Many theories have been advanced to account for the ability of the homer to find its way. Some explain that the bird is gifted with remarkable vision and is able to distinguish the immediate surroundings of its home from great distances. Others hint vaguely of electrical currents and subtle influences of the air. But the most reasonable explanation is the operation of the mysterious sense direction, common to all birds, developed and strengthened by the intensive training to which the young homer is subjected.

As soon as the young bird leaves the nest, it is placed in a position from which it can view the surroundings of the loft without having its full liberty. Pigeons of this age, getting their freedom without this gradual introduction, will often burst into flight and never return. After the young bird has become accustomed to the out-of-doors, it is allowed to walk out. Under favorable conditions, it quickly becomes settled, but the slightest fright at this stage may cause it to dash off in a state of excitement. When the baby fat begins to be replaced by the firm muscles of adolescence, the bird will begin to take daily flights, often of long duration, in company with its fellows. It thus becomes familiar with the country for several miles about.

Now serious training is begun. A particular direction is selected, usually chosen with regard to prevailing winds and other conditions, and the birds are worked toward that point of the compass by a series of tosses at gradually increasing distances. The first flight usually is half a mile, the second a mile, and so on until ten have been accomplished. The steps are then lengthened so that after the fifty-mile mark has been passed, jumps of from fifteen to twenty miles are made. When one hundred miles have been flown, the birds are sent to 150, 200, 300 and 400 without intermediate stations.

Four hundred miles is the greatest distance birds of the year usually are asked to accomplish, but exceptional youngsters occasionally have done 600. Five hundred miles is the most popular long distance race for old birds, but contests up to 1,000 miles are flown yearly. Eight hundred miles were acomplished in one day by a famous bird, but distances over 500 miles usually require more than a single day.

The speed at which the homing pigeons fly is one of the first questions that comes to the mind of the inquiring layman. This varies greatly with the distance, the shorter distances naturally being flown in much faster time. Flights of 100 miles, with a favoring wind, often are made at the rate of a mile a minute, or even better. Recent tests under the supervision of the Signal Corps showed that field messages sent by means of homing pigeons were delivered in much shorter time than by automobile or motorcycle.

The longest official distance flown by a homing pigeon was a flight from Denver, Colorado, to Springfield, Mass., 1,689 miles. A little more than twenty-three days were required for this feat, the bird flying only

by day, gleaning its food from fields and poultry yards as it came.

The fastest time for 1,000 miles is one day and eleven hours, a truly remarkable performance. This bird, rejoicing in the name of "Bullet," still lives in Fort Wayne, Indiana. It is a satisfaction to know that both these world champions were produced in America, giving assurance that the heritage of the now scattered lofts of Belgium has not been neglected in this country. Grandchildren of both these famous birds are included in the flock recently installed in the New York Zoological Park. Others of almost equally illustrious descent complete the new exhibit, which is proving of great interest to our visitors.

Automatic selection, operating through the medium of severe trials of flight, will leave us only the best individuals at the beginning of the next breeding season, when the product of our loft will be placed at the disposal of the Government. Especial thanks are due to Mr. F. C. Schmidt, secretary of the United Homing Pigeon Concourse, of Greater New York, for much valuable advice in our newest undertaking.

The Daïkon

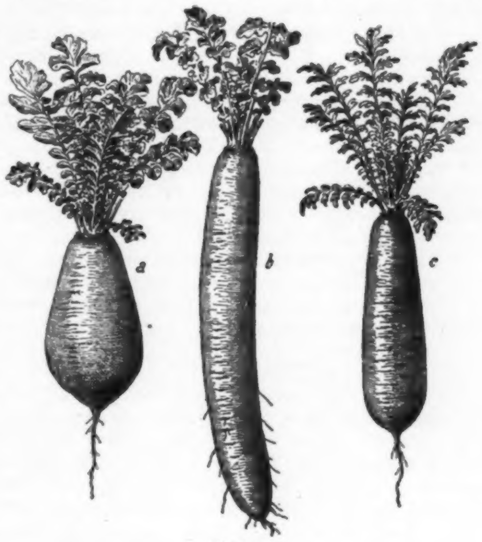
A food plant which is extensively used in Japan and whose virtues are such that it might make a desirable addition to the menu of both man and beast in our own country, is the Daïkon. This belongs to the Cruciferae, and its genus is the *Raphanus*, to which the ordinary radish belongs. Like the radish the Daïkon can be eaten raw, but it makes an excellent vegetable when cooked like turnips or beets. The foliage of the Daïkon is relished by animals and forms nutritious green fodder. The most productive varieties of the Daïkon (*Raphanus Sativus*) are the Shirimain Netzoumi, the Maru Nerima, and the Kedissune as shown in the accompanying illustration, for which we are indebted to "*Larousse Mensuel*" (Paris). The seeds should be sown during July and August in rows sixty to eighty centimeters apart, and covered with a centimeter of earth. They germinate four or five days after planting, and the harvest can be gathered in November. One of the marked properties of the Daïkon is the enormous size which the roots attain, their weight sometimes exceeding ten kilograms (22 lbs.). It is the largest roots which are most esteemed for human food by the Japanese, the smaller roots being fed to animals. The plant has been cultivated in Japan from the most remote antiquity, and great areas are devoted to it. It is planted as a second crop in succession to earlier crops, such as wheat, rice, peas, beans, hemp, etc. It requires no more cultivation than the turnip, and any soil which will grow grain is suitable to it, provided the earth is properly broken up. In countries where severe winter weather is not experienced, the roots can be left in the ground until needed. In regions having a rigorous climate, the crop is gathered immediately after the first frost, and placed in silos or cool cellars. The leaves are fed to rabbits, as well as to larger stock animals.

The Moons of Mars

We all of us have heard of Mars, that ruddy planet which gleams sometimes so brightly in the darkened sky. Mars has of late years been very much discussed, and some astronomers believe that it possesses inhabitants who are more or less intelligent. All of us know a little concerning Mars, as, for example, that it comes as near to us as 35,500,000 miles and goes as far from us as 234,000,000 miles. Most of us know, also, that this ruddy satellite of our Sun is about 1/7th as large as our earth.

But not as many of us have heard of the moons of Mars. There are two of these moons, and they are satellites revolving around Mars just as Mars is a satellite revolving around the Sun. But whereas Mars is a solar satellite having a volume about 1/7th that of our Earth these two martian satellites are very small bodies. Indeed, the larger of the two is probably less than 50 miles in diameter, the diameter of our own Moon being 2162 miles and that of our World about 7918 miles. Of course these two martian moons have been given names, "Phobos" (the larger) and "Deimos" (the smaller). Both were discovered by Dr. Asaph Hall in 1877. Deimos is farther away from Mars (about 14,600 miles from the planet's center) than is Phobos (5800 miles), although they are a great deal nearer their planet than our Moon is to us (a mean distance of 238,840 miles). Like our vastly larger Moon these very small bodies must be "dead" and sterile.

There is an exceedingly interesting and peculiar thing about Phobos, the inner one of these martial moons. It rises in the *west* and sets in the *east!* Now, were our Moon or Sun to do that unexpectedly how surprised and frightened we all should be! But the reason for such eccentricity on the part of Phobos is easily understood. Phobos revolves around Mars faster than Mars is revolving. That is, if we could stand upon a certain place on the martian surface we should see Phobos rise in the west, and, since both the planet and its satellite are moving in the same direction, the latter body would presently pass overhead and then set below the eastern horizon. This is the only one of all the known planetary satellites, including our Moon, to do such a thing. Our own Satellite revolves around the Earth slower than the Earth turns upon its axis, so



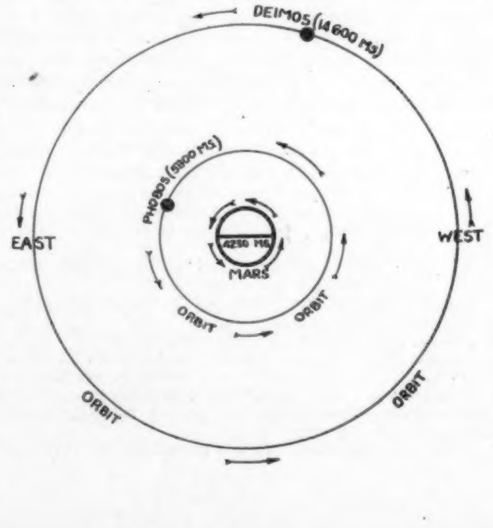
Daïkon

a, shirimain Netzoumi; *b*, maru nerima; *c*, kedissune

that the World seems to leave its Moon behind and she sets in the west, rising of course in the east. Deimos, the other satellite of Mars, has not the eccentricity of Phobos but rises and sets normally. We all of us have beheld our bright and beautiful Moon shining overhead and naturally we are wondering how Phobos or Deimos would appear were it to be put in this position of the Moon. Were Phobos so situated probably it would look a little larger than but not as bright as our own Satellite and Deimos would shine more noticeably than the planet Venus.—Charles Nevers Holmes.

Absorbtion and Phosphorescence

According to the law of Stokes the radiation energy absorbed by a substance is reemitted, as fluorescence or phosphorescence, at a smaller velocity or greater wave-length. Recent workers in America believe that they have discovered exceptions to this law. Dealing with the closely allied, but often divorced phenomena of "Absorption and Phosphorescence" in his Royal Institution discourse, Prof. E. C. C. Baly, F.R.S., of Liverpool, said that, like Continental investigators, he did not distinguish between fluorescence and phosphorescence, because there was no demarcation line, and that the exceptions to the law of Stokes were only apparent. The absorption bands were broad, and the law had to be referred to the central portion of a band. Plotting the intensity of a band against the wave-lengths (as abscissa) he showed that the absorption band and the phosphorescence band each had the sahape of an inverted V; the two V's overlapped at their bases, but the maximum phosphorescence was always on the red side of the absorption. For reasons which will presently become clearer, Mr. Baly pays particular attention



to the infra-red, which most workers have neglected, and for these studies he makes use of a spectrometer which has a rock salt prism, but only mirrors in the place of lenses; his other chief instrument is a Hilger spectrophotometer. Examining the V bands (or groups) he found that the ascending and descending branches of the V really consisted of a series of smaller V peaks (subgroups), culminating in the apex, and that the subgroups could further be resolved into lines. When the temperature was lowered, the lateral subgroups gradually disappeared, leaving only the central portions. Organic compounds, which were richer in bands than inorganic bodies, showed like the latter their fluorescence under kathode bombardment (they had to be cooled then, to avoid decomposition), but were more conveniently studied in vapors and in solutuons, when their color often changed with the nature of the solvent and the character (acid, neutral, alkaline) of the solution. These changes had been ascribed to changes in constitution—especially when compounds of colorless constituents assumed different colors under different conditions—but there was only a change in the vibration period. Determining the difference in wave-numbers (reciprocals of wave-lengths), *e. g.*, in the three main groups of β naphthol, Professor Baly found constant differences between the groups, in absorption and in phosphorescence again, he observed constant, smaller differences between the subgroups, and again smaller differences between the lines of the subgroups. In the case of sulphur dioxide the subgroups yielded the differences 11.79, 22.32, 35.32, the lines the differences 2.73, 4.32, 8.18. Now $2.73 \times 4.32 = 11.79$, etc., and the product $2.73 \times 4.32 \times 8.18$ was 96.43, which was the basis of the whole absorption spectrum. All the wave-numbers, moreover, appeared to be integer multiples (n=10, 12, 19, 23, 26, etc., in examples given) of a fundamental vibration in the infra-red. Professor Baly supported his arguments by many other striking figures of constant differences, exemplifying further the connection between the spectrum basis of a molecule (SO_2) and those of the constituent atoms (S,O) or of a compound (phenol) and those of its radicles (benzene, water). Residual valency in his view would be something akin to degrees of freedom of vibration, and the repetition of the fundamental frequency in multiples would look like a natural consequence of the quantum theory. It sounded all very convincing. But Dr. Baly has to correct his figures for solvent and concentration, and one has a lurking feeling about these and similar hypotheses that, once the quantum theory presumed — Baly accepts Bjerrum's formula for the connection between vibration frequency and rotational frequency of the atom—those constant differences may not amount to much more than algebraical gymnastics. Yet Professor Baly certainly predicted some of his regularities, and the considerations conform with his view. But there are electromagnetic fields of force in the atoms which are condensed on combination and opened up in stages by the absorption of light and the action of solvents, and that reactivity depends upon these forces. —*Engineering.*

Case-Hardening and Oil-Hardening

Regarding the relative merits of case-hardening and oil-hardening compositions, in certain kinds of service case-hardened gears are undoubtedly superior, while in others oil-hardened are best. As a general rule the oil-hardened gear can be counted on for steady uniform wear. Where a case-hardened gear is used the wearing down of the case to the core at any point means that the gear is gone. Similarly, if the case cracks it will flake, and the gear is gone. The actual cost of case-hardening will usually run slightly greater than that of oil-hardening. Oil-hardened gears always give a lower scleroscope hardness than case-hardened gears, but this is not a criterion of wearing quality, as the toughness of the material always enters in. For certain classes of service in certain gear design in automobile work, chrome-nickel oil-hardened gears, having a scleroscopic hardness of seventy to seventy-five, have been found to give absolutely satisfactory results, while in others sixty-five to seventy has proved better.—*The Engineer.*

Saccharine Regulations in France

The new rules for the sale of saccharine tend to favor the use of this product. Solutions can be sold in bottles containing at most 5 grammes of the pure substance. Compressed tablets can contain up to 0.025 grammes each. In all cases the price is not to exceed 2 francs per 5 grammes of saccharine in solution or in the solid state. This price includes the container, packing and all substances used for agglomeration in making up the tablets. Drug stores are not allowed to sell pure saccharine or any such product made up outside of the legal conditions, except, of course, for strictly medical purposes.

The Invasion of the Trenches by Rats—II

Its Causes and Its Remedies

[Concluded from Scientific American Supplement No. 2234, Page 259, October 26, 1918]

MEANS FOR DESTRUCTION

The very multiplicity of means for destroying rats proves that none of them are very efficacious. They are classified as follows by Khayatt[10].

1.—Mechanical Methods: (Various traps, stopping the holes, drowning by boiling water or tar).

2.—Natural Enemies: (Rat terriers, cats, etc.).

3.—Bacteriological Enemies: (*Bacillus Typhi Murium*, of Loeffler; B. Lacer, B. Mereshkowsky, B. Issatschenko, B. Danysz).

4.—Chemical Means: (Various poisons and asphyxiating substances).

Thanks to their intelligence, rats never let themselves be caught twice by the same artifice. It almost seems indeed that some of them are capable of interpreting the danger of a trap and benefit by the experience which has cost another rat its life. One inventor of an improved rat trap declares that there are "wise rats," which require special traps[10a].

1.—*Traps:* The various kinds of traps employed, including the Figure 4 trap, the pitfall, the divided collar which chokes the animal when sprung, the diminishing coil of wire, etc., are similar to those used for other predatory animals, and are too well known to require detailed description. Two special examples of the pitfall are worth noting, however, because of their simplicity and the limited amount of bait required. One of these was improvised by American troops in France, and consists of a barrel partly filled with water, within which a stick supporting the bait is stretched; extending towards the bait over the edge of the barrel is a board which operates like a see-saw. When the rat reaches the inner end, this tips, and drops the animal into the water. The first victim clings to the stick which supports the bait and utters cries which attract other rats to a like fate. Another pitfall common in some countries is suitable only for rural districts. This consists of a pit about four feet deep in the form of an inverted tunnel lined with slabs of stone at the side and the bottom. The first rat, attracted by the bait and being unable to climb the sloping stone sides, attracts others by its cries. The first rat attacks and devours the second victim, and this process goes on so that the original bait is all that is required. Another suggestion worth trying is that of an Italian engineer, who proposes to destroy the rodents by surrounding piles of provisions with a wire cable carrying a current of electricity; every rat which touches this will be electrocuted. Since these animals are very sensitive to electric currents the voltage required is not very high.

When stopping rat holes it must be remembered that one burrow is apt to have several exits, all of which must be stopped. A substance commonly employed for this purpose is cement mixed with pieces of broken glass; but unless destroyed within the burrow, or at one exit, rats can readily dig their way out.

NATURAL ENEMIES

Cats will not attack rats, and are in fact afraid of them. Dogs, especially rat terriers are far better. Sometimes the mere presence of a terrier in the house hitherto infested will drive away the rats. Usually, however, the terrier needs to be encouraged, directed and assisted by a skilled rat catcher in his work of elimination. It has been proposed to drive out the brown rat by his natural enemy, the Siberian Rat; but in this case the remedy would be worse than the disease.

BACTERIOLOGICAL MEANS

When the idea of destroying rats and other destructive animals by means of their bacterial enemies was first proposed it was received with great acclaim. At present, however, it has been almost entirely abandoned. The difficulty is to discover a germ virulent enough to cause a mortal epidemic among the predatory animals but at the same time so specific in its action that it will be without effect upon domestic animals and human beings.

In France we are sometimes tempted to believe that the only virus utilizable against the rat is that of Danysz[11] which has been adopted by the Pasteur Institute; but several others in the same category have been proposed, namely, those of Loeffler[12], Lacer[13], Mereshkowsky[14], Issatschenko. In practice, all these have shown themselves uncertain, and this is especially true of the Danysz virus. While effective at first it soon ceases to be so. The rats which have escaped the first distribution do not let themselves be caught by any following. But a still graver objection to the Danysz virus, and one which has caused it to be absolutely rejected since 1915, is the close similarity between its bacillus and that of paratyphoid fever. Some authorities declare that it is responsible for the diffusion of the epidemics of this fever which have taken place since 1892. This assertion was set forth in precise terms in an article by Lereboullet in 1916, and appears to have remained uncontradicted[15].

The natural resistance of the rat to infection remains and will remain an almost unsurmountable obstacle to its destruction by microbes. Danysz himself recognized the danger of his process.

CHEMICAL MEANS

The chemical means of destruction comprise all sorts of poisons and various asphyxiating gases. Many pastes to be spread on suitable bait contain phosphorus, arsenic or strychnine. The simplest form of phosphorus paste contains three parts of phosphorus to twenty-four of flour and one hundred and seventy-three of water (Schattenmann). This can be modified by adding various substances, such as sugar, butter and suet to make it more attractive. The French School of Pharmacy uses the following formula for arsenic paste: one thousand parts of melted suet; one thousand parts of flour, one hundred parts of finely powdered arsenic; ten parts of lamp black, one part of anise-seed essence. The great trouble with all poisonous substances is the danger to children and domestic animals. Moreover, as in the case of traps, the rats are extremely cautious about taking such bait when their suspicions have once been aroused. To protect bags of corn from rats it is recommended that they be soaked with a 1% solution of milk of lime[16].

There is, however, one suggestion in the way of special poison for rats which represents real progress in the matter. This is the proposition made a few years ago to employ squills. This contains a glucoside, called scillitine, which is a very active substance and which, while extremely poisonous to rats, is very slightly so for domestic animals, and for man. The Pasteur Institute, which prepares this poison from scillitine, has laid down a precise formula, giving all the directions to be observed to obtain a favorable result. This toxic extract is delivered in bottles which have been sterilized in the autoclave at 120° C. It is of such strength that one cubic centimeter is sufficient to treat five or six grams of bait. When more highly concentrated it fails, since it is then so bitter that the rats will not eat the bait. But this extract, unfortunately, must be employed when fresh, since it loses its activity at the end of three or four days. This fact offers a practical difficulty in many cases, and this is why the Service de Santé substituted in May, 1918, a fatty extract of scillitine possessing better keeping qualities than that furnished by the Pasteur Institute. Sometimes also powdered squills, which is much less fugitive, is employed. Loir Legangneux[17] described two methods for preparing this product: (1) Paste of squills consisting of 5 grams of powdered squills, twenty grams of flour, twenty grams of powdered fennel and one drop of anise-seed essence, mixed with ordinary grease to make a stiff paste, which is formed into tablets, weighing about ten grams. (2) Equal parts of powdered squills and chopped meat made into balls, weighing about five grams each.

To clear enclosed places of rats, especially the hulls of ships, poisonous vapors are often employed, such as those caused by burning sulphur and charcoal. Langlois and Loir[18] have demonstrated that Clayton gas is much more active than sulphurous acid, since it acts like sulphurous aldehyde. The Clayton apparatus is generally used in seaports in times of epidemic. In 1916 Galaine and Houlbert[19] presented before the Academy of Sciences an apparatus employing sulphurous anhydride. This consists of a receptacle containing the liquid anhydride, a receptacle holding boiling water and a small turbine with aluminum paddles driving a four bladed screw constituting a fan. The receptacle containing the anhydride is a steel bottle with walls three millimeters thick. Seventy-two grams of anhydride per cubic meter of air at a maximum temperature of 20° C. are required.

Carbon dioxide has also been recommended, but it constitutes too great a source of danger for the crew. Carbon disulphide is very toxic to rats; but is extremely inflammable as well as poisonous, and must, therefore, be handled with great care. Formic aldehyde can also be used, but it requires to act for thirty-six hours with an allowance of fifteen grams per cubic meter. The poisonous gases employed by the Germans in the present war, especially those containing chlorine, and sent over in the form of waves, have proved highly efficacious for destroying rats. Whenever I have had occasion to note the effect of these waves of gases in the trenches I have collected a great number of dead rats. In sewers chlorine vapors can be employed by pouring sulphuric acid on hypo-chlorite of lime (Raynaud). Loir recommends the poisoning of rats in their holes by acetylene. To this end a few pieces of calcium carbide are introduced into the rat hole. The opening is then stopped with earth and freely sprinkled with water. Brehm proposes a method of destroying rats by a mixture of malt and quicklime, with a little sugar. The intense thirst caused upon swallowing this mixture causes the rat to drink eagerly and he dies when he has drunk the quantity of water required to extinguish the lime.

Professional rat catchers are often very successful; one is on record who killed with his own hands 5,437 rats in 105 days. In extensive deratting operations the cost must be taken into consideration: bait, traps, poison, labor. One chief of a deratting crew has made a statement that the average cost of extermination is 7.50 fr. ($1.50) each.

Dr. Cayrel, in charge of deratting crews, declares himself satisfied with the results obtained: in a sector measuring approximately 270,000 sq. m., where deratting was practised from Dec. 9, 1915 till April 5, 1916, 46,000 rats were slain in these 4 mos., 9,000 by terriers and the rest by the scillitine of the Pasteur Institute. Yet these results were insufficient, though the work of the crews was satisfactory. It has been observed in fact, that sectors scrupulously cleared of rats are invaded with amazing rapidity when operations cease. The destruction of 50,000 animals is insignificant indeed in comparison with their rate of increase.

PROGRESSIVE AND WHOLESALE DERATTING

The struggle against rats has been generally unsuccessful because the problem has been attacked in the wrong way. There are two factors involved in their increase: the formidable geometrical progression in their increase, and, the available food supplies—the latter element conditioning the first. We have been constantly distanced in the race because we have confined ourselves to destroying adults while our negligence and bad hygienic habits have provided the mother animals with all the food required for excessive multiplication.

In the struggle against dangerous parasites success has frequently been attained when it has been possible to attack the parasite in those forms in which it is least resistant, and in the conditions which determine its increase. Let us recall the most typical examples. Flies have been brought under control whenever the dung heaps or garbage piles, where their eggs develop, have been eradicated. Again the Americans in Cuba achieved success in destroying the Anophelis as soon as the latter could find no stagnant water for their eggs

[10] Khayatt: The Destruction of Insects and Rodents as Prophylaxis for the Plague. Th. Paris, 1902.

[10a] This is entirely a question of odor. If a trap is thoroughly scalded with hot water after a rat has been taken it will be found just as effective as when new.—Ed. Note.

[11] Danysz: *Ann. de la Science Agronomique*, 1895, vol. 1. *Revue d'Hyg.*, 1900, p. 321. *Am. de l'Inst. Pasteur*, 1900, p. 193.

[12] Loeffler: *Centr. f. Bakt.*, 1892, vol. xii, p. 129; 1892, vol. xiii, p. 1; 1893, vol. xiv, p. 647.

[13] Lacer: *Centr. f. Bakt.*, 1891, vol. xi, p. 184; 1893, vol. xiii, p. 184; 1894, vol. xvi, p. 33.

[14] Mereshkowsky: *Centr. f. Bakt.*, 1894, vol. xvi, p. 612.

[15] Lereboullet: The Fight Against the Rats of the Trenches. *Paris Médical*, Aug. 26, 1916, p. 165. Letter by Dr. Vinache.

[16] Kossel and Nocht: *Arbeiten aus dem Kaiserlichen Gesundheitsamte* (Reports from the German Imperial Department of Health), 1901, p. 100.

[17] Loir and Legangneux: *Paris Médical*, Jan. 21, 1916.

[18] Langlois and Loir: Destruction of Rats on Board Boats. *Revue d'Hygiène*, 1902, p. 411.

[19] Galaine and Houlbert: *C. R. Acad. Sc.*, March 6, 1916.

to hatch and their larvae to develop. These remarkable examples indicate the following pronouncement: *In general man suffers from the attacks of a parasite when through ignorance or carelessness he feeds it and facilitates its multiplication.*

Applying this law to rats it may be said: *We are infested by rats when we suffer quantities of alimentary garbage to exist in our vicinity.*

It is to the increasing stringency in supplies of rations that I attribute the recent decrease in the plague of rats. To eradicate them both individual and collective measures are necessary. With respect to the former two admonitions must be ceaselessly reiterated:

1. *One has the number of rats he deserves by reason of his lack of neatness.*
2. *Any one who scatters food is breeding rats.*

Collective measures are merely supplementary and cannot absolve the individual from constant care. They consist first, in protecting provisions, and second in proper disposal of garbage. Three methods apply in the latter case:

1. To sprinkle with a denaturing substance, which however is not easy to find.
2. To cover the garbage pit with fresh earth daily.
3. To cover it with an iron grating.

Finally, and best of all, but difficult to apply in sectors in motion, is to feed the garbage to pigs. It is an axiom that *Garbage which is used for breeding rats is lost for the raising of pigs.*

"La Guerre pour le Minerai de Fer"

The above heading is the name given to the European War in a recent French newspaper, and it aptly illustrates a point of view which, although well understood in France, and perhaps a commonplace amongst those in this country who are conversant with the modern trend of the iron and steel industry, is very insufficiently appreciated by the British people as a whole. Few in this country have yet realized that this war, so often described by Germans with shameless cynicism as waged in defence of the Fatherland, is in reality carried on with the definite object of robbing France of a valuable possession which Germany neglected to annex in 1871, only because its real nature was not then realized. This object was carefully concealed during the first years of the war, but has been unthinkingly avowed of late, although it is true that the avowal was made only when Germany perceived that her specious disguise had been seen through.

The position can only be understood when the nature and extent of the great iron ore deposits that extend through eastern France and western Germany are known. This vast deposit of an iron ore known as "Minette" (a French name, by the way) underlies an area some 60 kilometers long from north to south and 15 to 25 kilometers wide. The ore occurs in beds interstratified with marls, forming, apparently, the topmost beds of the Upper Lias. The total thickness of this minette formation is usually from 30 to 60 meters, and within this thickness there are in most places from 1 to 5 workable beds of iron ore; these beds are known as grey, brown, red, yellow, black, etc., the thickness of the individual beds ranging from 1.5 to 5 and exceptionally up to 7 meters: it is rare that any one section contains a thickness of more than 15 m. of workable ore in several beds. The structure of the ore field is extremely simple, the strata dipping gently, from 3° to about 7° to the west; it is on this account that the eastern boundaries of the iron ore beds can be accurately defined by their outcrops, but the limits of their extension to the westward are not everywhere known. It was at first thought that these deposits could only be worked at and near their outcrops, but recent investigations have shown that the workable ore has very important extensions westward. The most important and persistent of all the beds is the so-called Grey Bed. It should be noted that all the beds are decidedly irregular in character, thickening and thinning out, becoming rich in places and in others so poor as to be unworkable. Owing to these barren zones, to the rather extensive faulting that the beds have undergone, and the intersection of the general level of the plateau, under which they lie, by numerous river valleys, the entire ore field is cut up into a number of separate areas or basins.

Mineralogically the ore is a poor brown hæmatite, the impurities being, in most cases, silicious, although some beds—the aforesaid Grey Bed in particular—are calcareous, this fact contributing largely to their value. Chemically the ores contain 25 to 35 per cent. of iron and so much phosphorus as to produce a pig iron with about 1.5 per cent. of that element.

The literature of the subject is most voluminous: good descriptions of the French and the German ore-fields are both found in the "Iron Ore Resources of the World," published at the 1910 Stockholm International Congress; the French have been fully described by P. Nicou, and the German in a number of papers between 1898 and 1911, by W. Kohlmann. English readers will find a short but clear description in Prof. Truscott's translation of the work on Ore Deposits by Beyschlag, Vogt and Krusch.

The minette deposits extend northwards into Luxembourg, they barely enter Belgium and extend southwards into German territory in the annexed portion of Lorraine, partly into the adjoining portions of France. Probably the most reliable estimate of the areas of the respective portions and their ore contents is to be found in the paper by Dr. Kohlmann published in *Stahl und Eisen*, 1911, Nos. 11, 12, and 14. His figures are as follows:—

	Area of workable minette, hectares	Estimated ore reserves, tons
France	40—50,000	3,100,000,000
German Lorraine	27—28,000	1,841,000,000
Luxembourg (about)	2,500	250,000,000
Total	70—80,000	5,191,000,000

A brief study of the history of these deposits makes the present position intelligible. It must not be forgotten that such ores possessed practically negligible value until Messrs. Gilchrist and Thomas invented the basic process of steel manufacture: it is quite certain that had it not been for this process, the minette deposits would never have assumed their present importance, and it is equally certain that but for this process Germany would never have been in a position to commence the present war. This great invention was not made until 1878, whereas Bismarck decided how much of Lorraine he would annex in 1871: had these dates been reversed it is also practically certain that the whole of Lorraine would have been taken by Germany. The ore deposits were known certainly before 1860 and were being worked at their outcrops about that time. In 1873, when working in the annexed portion of Lorraine began under German domination, the output was only 809,541 tons. Twenty years later this had risen to 10,683,842 tons, and in 1913 to 21,135,554 tons. The rise in the French output, commencing at a later date, is even more remarkable as shown by the following table:—

	Tons		Tons
1860	331,000	1900	4,446,000
1870	1,198,000	1905	6,398,000
1880	1,658,000	1910	13,137,000
1890	2,630,000	1913	19,883,000

It will be seen that the French production was increasing more rapidly than the German production before the war, and had the same conditions continued to prevail, it would, by this time, have unquestionably overtaken it. This circumstance appears to have aroused the cupidity of the great German iron-masters, and, no doubt, caused their readiness for a war which could not possibly have been waged without their consent. A study of the German literature on the subject makes this clear enough. In the first part of the German treatise on Ore Deposits, above referred to, published in 1909, the writers express the view that this deposit will guarantee the existence of the iron industry in Germany for a very long time. Then came the sudden increase in the French production, and in 1911 already German writers tell a different tale. Dr. Kohlmann bewails the fact that the Briey ore (the most important of all the French ore basins) is richer in iron that the German ore by fully 4 per cent., and expresses the fear that the importation of French ore into Germany will increase more and more, thus displacing minette of German origin. In 1913 again *Stahl und Eisen* suggested that increasing production of the richer French ore was causing large areas of the poorer German ores to be left unworked. As everyone knows, the first act of German aggression against France was to occupy these French iron ore fields, and ever since this occupation German writers have been proclaiming the intention of Germany to annex them permanently. On May 20, 1915, a Memorandum was submitted to the German Chancellor by a number of important technical and agricultural societies demanding the retention of this territory because "the security of the German Empire in a future war imperatively requires the posession of all the mines of Minette." Here it may be remarked that whilst the industrial societies are anxious to secure this source of iron ore, the agriculturists are no less anxious to obtain possession of the phosphorus that the ore contains. The yearly ore output of French Lorraine represents something like 400,000 tons of phosphoric acid, and this is an asset of no mean value. Over and over again do we find these same demands recurring in the German press and in German speeches. In February, 1917, a paper on this subject was published by Dr. M. Schlenker, Syndic of the Saarbrücken Chamber of Commerce, who maintains that what France and Germany are fighting for is the possession of the Briey ore basin, and quotes Prof. Max Krohmann who speaks of the war as the "coal and iron war in Europe." The writer states definitely that unless Germany had taken possession of the Briey ore basin at the very commencement of the war, it would have been impossible for the German iron industry to have covered the requirements of munitions of Germany and her allies. Seeing that Germany raised about 8½ million tons of iron ore from the Briey basin in 1916, this statement of Dr. Schlenker's is probably no exaggeration. He again wants to retain this ore basin in order to maintain Germany's military power, because he holds "that a country which commands unlimited quantities of iron ore and coal remains simply invulnerable in its most important sources of strength and power." In October, 1917, a Leipzig Pan-German paper, after pointing out that the iron ore output of annexed Lorraine represents three-fourths of the total German output, goes on to say that "if Germany keeps the mines of France and of Lorraine, she would have available fifty million tons of iron ore yearly. She would then possess the monopoly of iron ore in Europe. . . ." Finally, at the meeting of the Union of German Iron and Steel Manufacturers in Berlin in December last, the naked truth at last came out: reports were presented to the meeting showing that the German iron ore mines could only last another 40 to 50 years, and accordingly the iron and steel industry demanded that the iron ore basins of Briey and Longwy be retained in order to supplement the existing supplies. This report was followed by a paper by Prof. Krusch to exactly the same effect: he showed that the deposits of German Lorraine would only last for another 45 years, and actually had the audacity to attempt a demonstration that France could surrender these iron ore fields without injury to her own industry!

Shortly before this meeting a petition was presented to the German Government by the two leading German associations of iron and steel makers insisting on the annexation of the French ore fields. The same arguments are repeated: it is stated that if at the outset of the war France had been able to occupy the annexed portion of Lorraine, Germany and Austria would certainly have been compelled to surrender, whilst, on the other hand, the Germans have been able to manufacture the whole of their artillery munitions out of ore extracted from the French ore fields now occupied by Germany. The petition concludes with the significant statement that "the possession of Briey and Longwy would prove of incalculable value in the case of a future war."

Nothing more need be said: it is surely obvious that the war was undertaken by German with spoliation as one of its main objects, and with every intention of preparing forthwith for further wars of a similar nature. It is not clear whether the plutocratic iron-masters used the military party as a tool or *vice versa*, or whether the Emperor William was their dupe, or whether he cunningly used both in order to advance his own scheme of world-domination: if it be true, as is often rumored, that his interest in the great German iron-works is not purely platonic, the motives underlying his actions would be quite intelligible. It can only be hoped that one day the German nation will awake to the fact that they are being driven to slaughter in their millions in order that a group of immensely wealthy capitalists may yet further enrich themselves out of the spoils robbed from a neighboring State. It is clear that what Germany means by rectification of her frontier is the annexation of the French iron ore fields, and it is also clear that she will never willingly restore Lorraine to France, not that she attaches any value to the province as such, but that she does not propose to relinquish her grasp of the iron ores contained therein. The land she might give back, but the iron ore never—if she can help it!—*Jour. Soc. Chem. Ind.*

New High-Grade Lubricant

A new fruit containing a large percentage of oil has been discovered in the region of Torreon, and is known by the name of "chichopoxtle." Experiments show that 25 per cent of its contents consist of oil of great value in industrial pursuits requiring a lubricant of high quality. —*The Engineer.*

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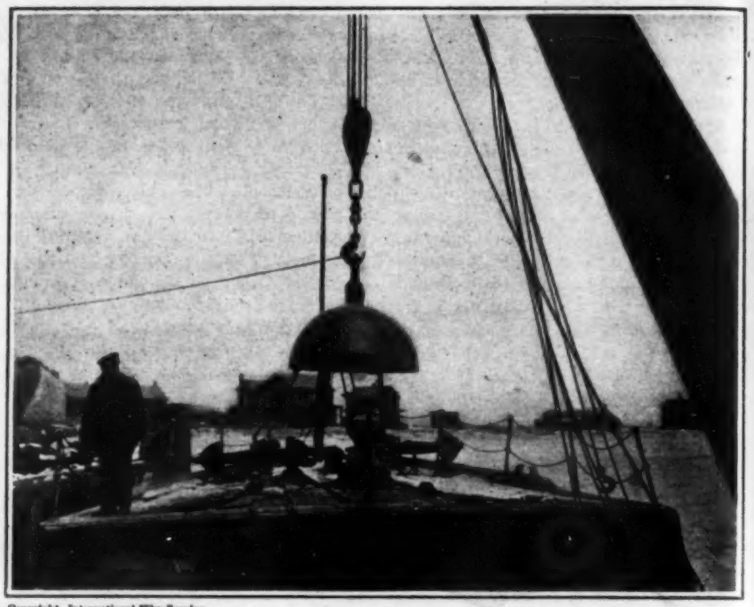
A bell buoy on deck of the tender. The action of the water on the paddle operates the submerged bell



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Heavy iron weights are used to moor buoys in their proper position instead of ordinary anchors

Nature's Submarines

How We Guard Our Commerce Against Them

EXTENDED accounts are frequently published telling of the ravages by the German submarines, and many statistics of the losses are given, but little is said of the serious destruction of ships by nature's submarines, the reefs and shoals that infest every coast, although these have caused a material decrease in the numbers of our commercial fleets.

On the open ocean our sailors keep a vigilant watch for signs of a lurking submarine, or for vessels; but on approaching the shore additional burdens are imposed on them in looking out for indications of under-water obstructions that may have as serious results for them as a collision with a torpedo. These indications are lights and buoys of varied character that mark the location of the unseen danger, or furnish a guide to the direction of a harbor or channel; and it is one of the duties of every Government whose territory borders on the sea to place and to maintain these beacons that are so necessary to the commerce of the world. In times of peace this work of placing and maintaining the guide posts of the mariner is diligently carried on by most of the leading nations of the world; but since the war broke out it has been found necessary in many places not only to suspend the maintenance of these beacons, but to remove them entirely, lest they become an aid to the enemy in making raids on the coast by fast cruisers, or a guide to aeroplane fleets in the skies. This is particularly the case with England and France where the German bases are but a few hours distant; and even if the buoys had not been voluntarily removed, and the lights extinguished, they furnished prominent targets for the enemy who has taken particular delight in their destruction. Even on our own coasts the same thing has occurred, and some of our light ships and buoys have been shelled by marauding submarines.

Even in the best of times, and with special exertions, it is really impossible to mark all dangers as distinctly as is desirable, for the ocean is vast, and the size that it is practical to give to any buoy or beacon is diminutive and difficult to distinguish in comparison; nevertheless, in this country particularly, a splendid organization and system has been built up by our Lighthouse Service, which maintains a greater number of aids to navigators than any other country in the world.

Our system of aids to navigation is really the result of the work of two Government Departments, the Coast Survey and the Lighthouse Service, the first making an exhaustive examination of the coastal outline, and the off-lying obstructions, while the latter is charged with the establishment and maintenance of all land and sea marks adapted for the purpose of aiding navigation. In the "Good old days" the way hidden reefs and shoals were located was by wrecking a ship on them; and when this had happened often enough, and the loss of life and property had become great enough to attract public attention, the authorities took cognizance of the matter, and, in the course of time, placed a mark on the dangerous spot. This system was not intentional, for, during many years, surveys were made according to the best known methods; but the under-water investigations depended almost entirely on soundings, and it is now evident how slight was the possibility of the sounder's lead discovering a sharp pinnacle of rock that juts up, solitary and alone from a great depth. On the Pacific coast such a pinnacle has been found whose tip has an area of but a few feet, and on every side the depth of water is over a thousand feet. As it is not practical to make soundings over every square foot of surface, but only at regular intervals, there is but slight chance that the sounding lead will alight in just the right spot. An interesting example of the shortcomings of the sounding method for making under-water surveys is found in New York harbor, where the traffic is denser than in any other port in this country. Not so very long ago a steamship drawing about 28 feet of water struck an unknown rock just off the "Battery," one of the busiest points in the harbor. Thousands of craft of every description had been passing this spot for years, and while the lighter draught boats passed in safety, the deeper vessels had evidently, by some miracle, always passed on one side of the rock.

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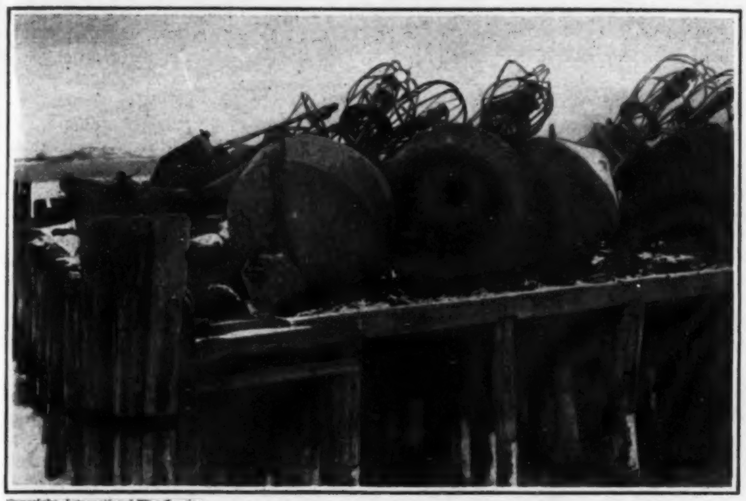
A large can buoy, made of steel plate. Some of them weigh over four tons

The modern method of making under-water investigations is by means of the "wire drag." A long steel wire, weighted to keep it down, and supported at intervals by floats to hold it at the depth it is desired to examine, is attached at each end to a power launch, and it is thus dragged over the area under investigation. If any obstruction projects above the predetermined depth to which the wire is adjusted, the latter is caught and the location of the obstruction is indicated by the supporting buoy nearest to the obstruction. It then becomes a simple matter to further investigate the nature and size of the obstruction, and to accurately locate it upon the chart. Our entire coast is now being searched by the U. S. Coast and Geodetic Survey by this new method, and many surprising developments are resulting, which will make navigation safer and more certain.

Besides the search for hidden reefs of rock our surveyors are constantly on the alert watching the sandy shores, for here the ceaseless action of tides and currents is continually changing the coast line, the location and size of sand banks and of channels and harbor approaches. It will be seen that there is a constant contest between nature and man; and while such obstructions as can be permanently removed are being dealt with as rapidly as possible, those that remain are marked to warn the navigators of their presence and position.

The marks that warn and guide ships on our coasts consist mainly of light houses, light ships, buoys and beacons. Light houses are the principal guide posts that warn the navigator of his position, and the light ship performs the same general function; but there are innumerable spots where these agencies cannot be employed, or cannot give the detailed information required, and here the useful buoy proves its value. Buoys are of great variety, both in shape, size and character, these features depending on the location and nature of the information they are intended to convey. For the dangerous outlying reefs and shoals, such as have been above considered, very large buoys are employed and these are usually equipped with a light, whistle or bell; and many have both the light and one of the sound producing devices as well. In exposed positions in the open waters off the coast a large buoy is necessary, both to render it easily visible in the rough water, and to withstand the buffeting of storms and ice; some of the plain can and nun buoys being from 25 to 30 feet in extreme height, and weighing as much as 8,300 pounds, while some of the combined light and whistling buoys run to over 34,000 pounds with an extreme height of over 50 feet. Of course the greater part of these buoys are under water, and not visible, as a large displacement is necessary to float and support the tall and heavy superstructure.

No matter how large and conspicuous a buoy may be it is difficult, or impossible to distinguish it during a dark nght, so many are provided wth lanterns that show a warning light. This light, which is operated by



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A number of large gas buoys that have been taken in because of the war

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Making a gas buoy fast alongside the tender for repairs and recharging

compressed gas, either oil or acetylene, burns constantly, both day and night, from a month to a year without recharging, according to circumstances. If the light is of the flashing variety, there is a small pilot light that is always alight, while diaphragms, controlled by the gas pressure, operate valves that open the flow of gas to the main burner at the prearranged intervals so that the buoy may send out its distinguishing signal. To provide for foggy weather, whistles or bells are provided, and a few special buoys have all three means of warning, light, whistle and submarine bell. These whistles and bells are all automatic in their action, being operated by the motion of the waves. In one arrangement the buoy carries a steel framework on its deck, in which is hung a large bell and four free-swinging hammers, which strike the bell irregularly as a result of the motion of the waves. The submarine bell, on the other hand, is hung at the extreme lower part of the structure, and is operated by a vane, or paddle, which swings with the wave motion. One of the accompanying illustrations shows the operating parts of one of these under-water bells quite distinctly. The whistle is also operated by the wave motion. A large tube, that extends vertically through the tall buoy, is open at its lower end, but closed at the top, where the whistle is mounted. A check valve in the top opens, and admits air, when the buoy rises on a wave. When the buoy drops again, this air is compressed and is forced out through the whistle, thus producing the warning sound. Of course these warning sounds are very irregular and depend largely on the roughness of the waters in which they are located.

In 1915, when the last statistics were reported, there were 479 lighted buoys in the waters of the United States, together with 50 submarine bell-buoys, 86 whistling buoys and 6,488 other buoys. Besides these there were 1,662 lights; 2,837 minor lights and 53 light vessels; and to care for these we had only 47 vessels of various sizes. The magnitude of the task assigned to these tenders may be imagined when it is said that not only must they provide supplies of every kind to the numerous isolated light stations, but that every one of the thousands of buoys that guard our shipping must be relieved at least once every year for painting and overhauling. Moreover, all these buoys are liable to be carried away, dragged from their positions, capsized or sunk as the result of ice, storms, collisions or other accidents, when immediate attention must be given to the case. It is no easy matter to hoist out, or place an immense, unwieldy structure weighing as much as 17 tons, even in the best of weather, and with the smoothest of seas; but much of the hardest work comes during the winter months, which makes the task much more trying.

The illustrations show a few of the various phases of the work of the tender, and how they are constantly on guard against nature's submarines; but at the present time the aditional task is imposed upon them of sweeping for the mines that have been dropped in considerable numbers along our coasts by the raiding German U-boats during the last few months.

The Men Who Build Our Ships

More than half a million men are at work on the record-breaking shipbuilding program of the United States. The shipyards alone employ 300,000 men and 250,000 the board's gigantic program.

Sixty per cent of the labor, says an official account of the details of this work of building an American merchant marine, is used in constructing the hull and 40 per cent in the making and installation of the mechanical parts that operate and run the ship. The story of the work they do is particularly interesting because of the great demands that are being made upon less essential trades to recruit the ranks of these more important workers.

The important trades which help to build a ship of steel are the following: Shipfitters, blacksmiths, riveters, chippers and calkers, drillers, plumbers, pipefitters, machinists, joiners, carpenters, pattern makers, foundrymen, coppersmiths, heavy forgers, sheet metal workers, furnace men, shearers, punchers, anglesmiths, shipwrights, riggers, flangers, drop forgers, erectors, bolters-up, crane men, locomotive engineers, firemen, loftsmen, laborers, painters, and helpers in all these trades. In the actual construction of the hull of the ship the more important trades employed are: Loftsmen, shipfitters, drillers, riveters, chippers and calkers, shipwrights, riggers and shopworkers.

Loftsmen play a large part. The plans of the ship, as made in the drafting room, are drawn to small scale. These are sent to the mold loft—a large building with a smooth floor of sufficient size to have drawn upon it the plans of the ship to full size. This is the work done by the loftsmen. The lines of the ship consist of three different plans called the sheer plan (side elevation), the half breadth plan and the body plan (end elevation). These three plans give the shape of the ship. From them templates or molds can be made by the loftsmen. These templates or molds are light wooden or paper patterns from which the steel for the various parts of the hull can be laid off and marked for shearing, punching, planning and other operations.

The plan most used in making templates is the body plan—which shows the shape of each frame, beam and floor plate—and this usually is marked off on a special section of wood flooring (called the scrieve board) and cut into it permanently with a service knife. Among the duties of the loftsmen are: to lay down and fair the lines on the mold loft floor, to make the scrieve board and the various molds or templates for the parts of the hull. This work requires much experience, skill and the highest kind of mechanical training.

Probably the one metal worker whose trade may be said to be purely a shipbuilding trade is the shipfitter. His work consists in marking off the steel material for different parts of the ship's hull. This is done usually by means of a template lifted or marked off from other parts already in place on the ship. In some cases the material is marked off directly without the use of a template, from dimensions taken from a blueprint or other plan.

Drillers are used extensively. Workmen of this class do both drilling and reaming. This is because a large portion of the rivet holes in the different parts of a ship are punched in the shop before the parts are erected, but in some cases the holes must be drilled on the ship. When the parts that are punched are fitted in place, in spite of the most careful workmanship, it will usually be found that many of the rivet holes in connecting pieces do not come quite fair, that they overlap slightly. These unevennesses are removed by reaming, which consists in slightly enlarging the holes so as to make them fair and perfectly cylindrical so that they will be completely filled by the rivets. Riveters do a spectacular work in the construction of a ship and the rat-a-tap of the pneumatic driving force they use in their work has a fascination like the anvil in the old village blacksmith shop. Each rivet must be driven carefully, exactly as called for by the plans. When the ship is designed each and every rivet is specified.

Chippers and calkers are used to trim off or smooth up the edges of plates, castings and other parts. This is done by the chippers using hand or pneumatic tools. These same workmen, usually, are also engaged as calkers. Their duty is to calk the edges of plates, angles, rivet heads and other parts to make them watertight. This is done after the riveting is completed.

Shipwrights are the men who instal wood decks, wood foundations for capstans, winches, guns and other parts. They also do the work of making and installing wooden masts, spars, booms, etc. They also have considerable work to do in connection with the preparation of launching ways, building blocks, shores, wedges and parts of similar character. Their work is distinct from woodwork or stateroom fittings, furniture and other woodwork of similar nature that is done by the joiners. Riggers work in the manufacture and installation of shrouds, stays, lifts, braces, life lines and other rigging fitted to the masts, spars, booms and other parts of the ship. Some of this rigging is made of steel wire rope, some of hemp or manila rope. The riggers must be able to do splicing, seizing, serving and parceling.

Workmen employed in the shops of a shipyard comprise a variety of trades. For example, a large amount of the woodwork of a ship is done in the shop by the joiners. Ventilation, piping and all light metal plating work is done largely in the shop by the sheet metal workers. Plumbing and piping work is done to a large extent in the shop by the plumbers, machinists and pipefitters. Forgings for a large number of miscellaneous fittings and other parts of the ship are made in the shop by blacksmiths, drop-forgers and heavy forgers. Much of the work on wiring and electrical fittings is done in the shop by electricians.

The shop work on the hull proper, or the fabrication, as it is sometimes called, is done by the workmen who operate the shears, punches, bending rolls, planers, and other shop machines, and the frame benders, acetylene burners, furnace men and anglesmiths who do the work necessary prior to erection on keel plates, shell plates, brackets, clips, beams, bulkhead and deck plating, stiffeners and other parts required for the hull of the ship.—*From The Iron Age.*

Crystals in Filament Form as Used in Electric Incandescent Lamps

The effect of work on a tungsten filament is to convert the metal into the labile elastic form which reverts to the crystalline at high temperatures. Crystal boundaries are produced which are points of weakness and readily fracture. In the process of J. Pintsch (Fr. Pat. 469,212 and Ger. Pat. 304,857) this is avoided by producing a filament consisting of one homogeneous electric crystal. A drawn and sintered thread is made of tungsten with the addition of 2% of thorium oxide which acts as a catalyst, and its micro-structure is found to resemble a bundle of crystals of octagonal section. The filament is drawn through a cylindrical electrically heated furnace with a zone at 2,400°-2,600° C. and an atmosphere of hydrogen. The rate of motion—about 25 metres per hour—is somewhat slower than that of crystal growth. The crystals, already existing, grow and coalesce so that at the end the whole filament consists of one crystal, which cannot therefore grow on further heating or develop new crystal junctions. The filaments show a high degree of pliability which is very permenent in use.—*Note in Jour. Soc. Chem. Ind. on an article by F. Schroter in J. Gasbeleucht.*

Cider Apple Jelly*

By B. T. P. Barker

After the outbreak of war in 1914 one of the chief objects on which the attention of those engaged in agricultural research was focused was the avoidance of waste of any agricultural material of food value. The cider apple crop that season afforded a particularly good example for study, since the yield was heavy, and the price of cider apples so low that thousands of tons of fruit were wasted because the farmers did not consider it sufficiently profitable to gather. During September, 1914, the basis of the method of converting this fruit into a palatable product for human consumption, which is described in this paper, was worked out: but the occasion for utilizing it on a commercial scale did not arise until 1917. The manufacture of the jelly was organized by the Bristol University Research Station at Long Ashton, where most of the actual work was carried out.

The immediate object of the work was to utilize for human consumption the 10% or so of sugar (approximately ⅘ invert sugar and ⅕ sucrose) in the fruit. The most satisfactory plan proved to be the production of a form of apple jelly by concentration of the juice without the addition of sugar. With cider fruit fetching 20*s.* per ton and less, a cheap and palatable jam substitute was thus produced.

Cider apples may be divided into three main groups:—(*a*) sours, (*b*) sweets, (*c*) bittersweets. The sours are distinguished from the other two classes by their relatively high content of malic acid, the amount in the average case well exceeding 0.45% of acid in the juice. The acidity of sweet and bittersweet apples is normally much below that figure. The only difference of importance between the two latter classes is that the bittersweets contain appreciable quantities of tannin, which occurs only in very limited quantity in the sweet varieties. For present purposes these two classes may be treated as one, since their mode of use from a food point of view is identical.

Hitherto it has only been the sour varieties which have been drawn upon to any extent to make good any deficiency in the crop of ordinary table apples. Their utilization presents no difficulties, the quantity of acid contained being sufficient to furnish the necessary cooking qualities for culinary purposes, and the "setting" or "jellying" properties for jam-making. Arrangements were therefore made in the West of England for the 1917 season to deal extensively with this class of fruit for the production of apple pulp for jam-making, and the major portion of the apples pulped at the respective centres organized there as well as those despatched to other stations in other parts of the country were of this type.

The other types, however, have not been utilized previously to any extent on a commercial scale for food purposes, and the work in this direction which has been carried out during the 1917 season must, therefore, be regarded as largely of an experimental character. The form of product which it was decided to make was the type of apple jelly evolved as the result of experiments carried out at Long Ashton in 1914.

Method of making jelly. The general method of making the jelly has already been outlined. The actual details of the process, as generally carried out, are as follows:—

The fruit to be dealt with should consist mainly of sweet or bittersweet varieties or a mixture of both types. A limited proportion of sour apples in the mixture is permissible, but it should in no case exceed one-third of the total quantity, and not more than one-sixth should be allowed if the jelly is made without added sugar. The object is to secure that the percentage of malic acid in the finished jelly shall be between 1 and 1.5%. The exact amount desirable is a matter of taste; for most palates, an amount below 1% results in a jelly too insipid and sickly sweet in flavor, while anything exceeding 1.5% is too sharp. It is obvious that the degree of acidity requisite in the unconcentrated juice must depend upon the extent to which the concentration is to be carried, *i. e.*, upon the percentage of sugar. Approximately 65% of total sugar is needed in the jelly: hence the quantity of sugar in the juice before evaporation, whether natural sugar only, or natural *plus* added sugar, determines the extent of concentration required. At Long Ashton it was the practice to test the acidity and the sugar content of every lot of juice used, adjusting the acidity to the calculated quantity needed by the addition of sharper or less acid juices as the case might be.

Natural apple juice in an average season contains about 10% of total sugar. The juice, therefore, must be reduced to about 1/7 of its original volume, if no other sugar is added. It is found in practice more economical to add approximately the same amount of sugar as occurs naturally in the juice. The extent of concentration required is then reduced by one-half, a larger yield of jelly is obtained from a given weight of fruit, and there is a considerable saving of time. The quality of the jelly is also considered by most people to be superior. The added sugar may be either cane sugar, glucose, or corn syrup. In most cases during the past season a mixture of equal parts of cane sugar and corn syrup was used and gave very satisfactory results.

The requisite plant for jelly-making consists of a mill and press, for extraction of the juice from the fruit, and an evaporator, for the concentration of the juice.

Mills and presses. Ordinary cider mills and presses serve perfectly well. At Long Ashton an American type of "grater" mill and a hydraulic press, used at the Research Station for cider-making, were available. The yield of juice per ton of fruit with these machines averaged 150—170 gallons according to the period of the season.

Evaporators. It has been possible as a result of the season's working to obtain important information as to the most efficient type of evaporator for this particular purpose. The simplest form is the ordinary steam-jacketed jam-boiling pan. This is the least satisfactory type of apparatus, since it is not a continuous working form, and the whole of the juice dealt with in one operation has to be subjected to a high temperature until the volume is reduced to the required point. This involves a relatively long period of cooking with consequent partial caramelization of sugar and, therefore, considerable darkening of color and the acquisition of a more or less distinct burnt flavor. The "setting" property of the jelly is to some extent affected. The process is also comparatively slow. The usual type of steam-heated vacuum boiling pan is an improvement, but is also open to the objection of not being continuous in its working. Caramelization is, however, considerably reduced, and color and flavor accordingly are improved. The speed of evaporation is increased, but the output does not reach that of a continuous working apparatus.

Another type of evaporator used was one constructed on the lines of certain American juice evaporators. It consists of a long narrow wooden trough divided into two compartments by a partition. The two compartments are entirely separated from each other by this at one end, the fresh juice being fed into the one division at the end and the outlet for the concentrated juice being situated at the corresponding point in the other compartment. The two compartments communicate at the far end, where the partition does not extend quite the full length of the trough. The bottom of the trough is made slightly sloping so that the incoming juice flows along the first compartment to its point of communication with the second, and thence returns along the latter to the outlet. Three copper steam pipes are fixed just above the floor of the trough in each compartment, and these are heated by steam at 80 lb. pressure. By regulation of the rate of feed of juice the desired degree of concentration is obtained. A wooden cover is fitted over the whole trough and a central flue to carry off the evolved steam from the boiling juice is provided. This evaporator has the advantage of being continuous in its workings, but proved to be difficult to regulate. Variations in steam pressure affected the rate of flow to such an extent that constant attention was required, and a number of other causes contributed to produce such serious irregularities in the flow that occasionally the steam pipes near the outlet would become partially uncovered, leading to burning of the concentrated juice, while at other times juice incompletely evaporated would be delivered. It was with great difficulty, therefore, that anything approaching uniformity in the product was obtained. The speed of the apparatus proved to be much slower than had been anticipated, and the cost of concentration was accordingly relatively high. The quality of the product was, on the whole, fair; the color was generally rather too dark and the flavor at times indicated traces of burning. The jelly as a rule set moderately well, but showed a tendency to be hygroscopic, and during damp periods in December liquefied somewhat. Under drier conditions this is now setting again. The principal drawbacks of the apparatus are the slow rate of output, the high cost for concentration, and the difficulty of securing uniform working.

The apparatus mainly used at Long Ashton was the Kestner evaporator. In essentials, it consists of a continuous series of copper tubes, on the interior surface of which the juice travels as a thin film. The tubes are heated externally by steam under pressure, and the juice in its passage through them is gradually concentrated. The most suitable pressure found during the past season's working with apple juice was about 30 lb. A special arrangement at the delivery end of the tube system provides for the separation of the evolved steam from the concentrated liquid. The machine is a continuous working one. It can be operated with the treated liquid under ordinary or reduced pressure. No vacuum pump was provided for the first season's trials at Long Ashton, and consequently the whole of the work was done under ordinary pressure: but there is no doubt that the reduced pressure would give decidedly superior results as regards quality of product, rate of output, and cost of evaporation. For future work in this direction it is likely to be adopted. Another improvement which should in future be incorporated is to pre-heat the juice before it enters the evaporator by means of the steam given off by the juice.

Condition of juice. Experience in the making of cider has shown that the yield of juice is determined by the condition of ripeness of the fruit at the time it is milled and pressed. Both unripe and over-ripe fruit—particularly the latter—yield less juice from a given weight of apples than fruit which has reached a well-ripened condition. The "setting" quality of the juice is similarly much affected by the state of ripeness of the fruit. The juice from unripe or much over-ripe fruit sets less well after concentration than that from perfectly ripe apples. Up to a point a certain amount of over-ripeness may assist rather than hinder "setting," and it is probable that the fruit should be left over to a somewhat more advanced state of maturity than is desirable from the point of view of yield of juice, if the maximum "setting" quality is aimed at. It is preferable, therefore, that the fruit should be thoroughly well matured before extraction of the juice, even if a portion is distinctly over-ripe, rather than it should be milled unripe, unless steps are taken to ensure good setting by the use of pectin extract, concerning which information is given below.

Extraction of juice. There are no points of particular importance in connection with the extraction of the juice which require notice. The methods found most satisfactory in cider-making apply equally in this case.

Supplies of juice. In preparing quantities of juice for evaporation it is desirable to provide at one time no more than is required for one day's working of the evaporator. Juice more than 24 hours old is liable to show the beginnings of fermentation, particularly during the warmer parts of the season, and, when this occurs, its "setting" qualities suffer owing to changes in its pectin constituents. An attempt was made to overcome this difficulty by treating the juice with sufficient sulphur dioxide to arrest fermentation for a few days: but, although the juice can be retained fit for jelly-making in this way even for so long a period as a fortnight or more, the jelly does not set readily and the method cannot be recommended except for emergencies caused by an over-supply of juice. At the same time it is desirable to provide at the start of each day a sufficient bulk of juice to last throughout the day. If this is pumped into one large vat, it ensures that the whole of the day's output is uniform in character. At Long Ashton two blending vats, holding about 750 gallons each, were used, the contents of the two sufficing to keep the evaporator running for a working day of about 15 hours.

Standardizing acidity of juice. The acidity of the supply of juice provided is brought to the required standard by blending as already described. It has been shown that this standard is determined by the degree to which concentration is to be carried, *i. e.*, according to whether sugar is or is not added. As mentioned in the beginning of this paper, the method found most advantageous is to raise the content of total sugar in the unconcentrated juice to approximately 20% by the addition of cane sugar or corn syrup or a mixture of both, in which case the standard of acidity is taken as about 0.35% of malic acid and concentration is carried to about 4/7 of the original volume.

Use of sugar. When supplies of sugar in some form are available, its use is advised for the reasons already given. If cane sugar is exclusively used, the flavor of the jelly is sweeter and its consistency generally firmer. Corn syrup alone, consisting of a mixture of glucose, maltose, and dextrin, yields a less sweet article, and there is a tendency for the jelly to be more sticky or treacly. A mixture of cane sugar and corn syrup in equal parts gives results little, if any, inferior to cane sugar alone.

Jelly made without added sugar is more intense in flavor, its color is deeper, and particular care to avoid caramelization during the making is necessary. It is, however, possible to make a palatable article without added sugar; but the yield of jelly from a given weight of fruit is considerably less, and when the price of

* *Journal of the Society of Chemical Industry.*

apples is about £3 per ton or upwards the cost of the jelly works out at a slightly higher rate than when sugar is added. The latter point simply resolved itself into a question of relative prices of apples and sugar.

It is better to add the sugar before than after concentration of the juice, since, although more steam is required for concentration, it is not easy to dissolve the sugar and obtain an even mixture in the thick, syrupy, concentrated liquid.

Use of pectin extract. The investigations on pectin compounds which have been conducted at Long Ashton during the past four years have shown that the following three conditions are necessary for a proper "gel" formation, *viz.*, (*a*) the content of total sugar present in solution—whether cane sugar, glucose, or some other suitable carbohydrate, either singly or in mixture—must approach 60-65%; (*b*) an acid of some kind, preferably malic, citric, or tartaric acid, must be present in quantity approximating at least to the equivalent of 1% malic acid, and (*c*) a suitable form of pectin must also be present in quantities of 0.5% or upwards. In many samples of apple juice dealt with in the course of this work, with the acidity raised to the standard adopted as being most suitable for jellymaking, these three essential conditions were easily obtained in the finished product when the fruit handled was in reasonably uniform condition as regards ripeness and was milled when well ripened. Even when the fruit was somewhat over-ripe no serious trouble was experienced; but badly over-ripe fruit as well as unripe or unevenly ripe samples caused uncertain results, mainly on account of pectin deficiencies. Since in practice the condition of the fruit generally is very variable, it was considered advisable during the greater part of the season to add a limited quantity of pectin extract to the juice before evaporation.

The extract was made by passing waste steam from the evaporator into a mass of pressed apple pomace, plentiful supplies of this being available. After being steamed for some time, the mass was placed under the press and as much liquid as possible extracted. This fluid, which was thick and mucilaginous and contained considerable quantities of pectin, was added to the juice at the rate of 15 gallons of extract to 100 gallons of juice. When this method was adopted, the jelly could be relied upon to set well, provided that the juice was not over-cooked in the evaporator. With the extract an additional quantity of sugar was used (15 lb. of sugar to 15 gallons of extract) to avoid dilution of the juice in respect of that constituent.

The use of the crude pectin extract prepared in the manner described is mainly for the purpose of ensuring the proper "setting" of the jelly: but it also affects the yield from a given weight of fruit. Practically it amounts to the addition of 15% to the volume of the fresh juice handled with a corresponding gain in the final amount of jelly. It occasionally results in a still greater increase in the yield of jelly, since some juices without it have to be concentrated to a smaller bulk than that normally requisite in order to give a sufficiently firm "set."

Some preliminary experiments with an improved form of pectin preparation suggest that an appreciable reduction in the cost of production should be possible, provided that the value of sugar as compared with that of the fruit does not vary materially from the ratio obtaining during the 1917 season. The preparation in question also promises to simplify the problem of making the jelly set and to yield a superior product.

The addition of the pectin extract does not reduce the strength of the flavor to an appreciable extent. The acidity is slightly reduced, but this can be adjusted by modifying the standard of acidity in the unconcentrated juice by suitable blending.

Clearing of juice. The fresh juice as it is received from the press is a turbid liquid containing variable amounts of particles of apple pomace in suspension. The removal of the coarser particles is essential and is readily accomplished by straining the juice, as it is pumped into the blending tank, through a filter bag made of canvas or other suitable material of moderately fine mesh. By that means the juice, while still turbid, is freed fairly completely from suspended solid matter, the turbidity being mainly caused by pectin compounds in solution. A further filtration of the juice is arranged as it is fed to the evaporator, the end of the suction hose of the supply pump being covered with fine-meshed straining cloth.

The turbidity of the juice disappears almost entirely in the final stages of its concentration in the evaporator. This is believed to be due to the interaction of the sugar, acid, and pectin contents, and the comparatively sudden change from opacity to relative transparency which occurs apparently at or about a given point of concentration is regarded as indicating that the "jellying" stage has been reached. In practice it constitutes a safe guide.

The jelly prepared in this way without more elaborate attempts at clearing is semi-transparent when cold, a certain amount of haziness developing as it cools.

Concentration of juice. A supply pump provides a continuous flow of juice into the evaporator, the rate of which can be regulated as required. This is determined by the specific gravity of the concentrated juice. It is considered necessary that the jelly should possess a total sugar content of 60—65% to ensure adequate keeping and setting properties. This is equivalent to a specific gravity of 1.35 at 15° C., which corresponds to about 1.3 at the temperature of the concentrated liquor as it is collected from the evaporator (about 95° C.). The whole rate of working of the apparatus is therefore controlled by the specific gravity of the concentrated juice. This is taken at frequent intervals with a hydrometer, the standard gravity adopted being 1.3 for the hot liquid. When the gravity reading is too low the rate of supply of juice to the evaporator is slowed down, and when it is too high the supply is increased. Another means of controlling the rate of concentration is to regulate the steam pressure of the evaporator. By the combination of this method with that of regulation of the supply of juice, it is not difficult with the Kestner apparatus to maintain the specific gravity of the concentrated liquor at any point required. Control is similarly obtained with the American type of evaporator, but exact regulation is more difficult, and closer and continuous attention is needed in this case.

Output. As regards output the Kestner evaporator at Long Ashton was capable of dealing with 100 gallons of the prepared juice per hour under fair average conditions of working, giving an average production of about 275 lb. of jelly per hour. Under specially favorable conditions the quantity of juice per hour used advanced occasionally to 110—120 gallons. These figures refer to cold juice only. In a trial where the juice was preheated to 75° C. before entering the evaporator, the juice supply per hour easily reached 125 gallons. Probably an appreciable increase in these figures would have been recorded had a larger steam boiler been available. That used had to be run at full capacity the whole time in order to maintain the steam pressure in the evaporator near 30 lb. per sq. inch.

Substitutes for Glass

EVEN in this country where we are 3,000 miles away from the guns of the Huns the shortage of glass has made itself seriously felt with corresponding rise in price and with the attendant difficulties felt by milkmen, manufacturers of bottled goods, and even the thrifty housewife, trying to do her bit both for Uncle Sam and her family by preserving fruits and vegetables.

In France where heavy bombardment has been going on for four years the losses in window panes and glassware of all kinds are naturally many times as great. This is so seriously felt especially in those regained areas where the work of reconstruction has already begun, that many ingenious substitutes are being proposed.

One admirable suggestion is that window space shall be divided by bars of lead, wood or other suitable material into small partitions as was the common practice among our ancestors, to which the diamond shaped panes in old houses bear witness. Large panes which have been cracked can be cut up to fill these smaller spaces. Another advantage is that small panes can be shipped with much less expensive packing and with far less loss by breakage than the large sheets to which we have become accustomed.

Another proposition is to make use of various substitutes which lack the perfect transparency of glass to fill the windows of cellars, stables, garages, etc., where a bright light is not required.

The great Fairs of Lyons and of Paris recently held made a special feature of the exhibits of such substitutes. We are indebted to *La Nature* (Paris) for an interesting list of these glass substitutes, both transparent and merely translucent.

Siloxide is a glass having a blue tinge; it is composed of silica and certain acid oxides such as those of zirconium and of titanium. Artificial mica is made by mixing 45.5 parts of green sand with 12 parts of bauxite and 30.5 parts of calcined magnesia, the mixture being fused in the electric furnace; 14 parts of alkali are then added to 90 per cent of this and it is allowed to cool slowly. While these products are transparent they are comparatively costly. There are various derivatives of cellulose, however, which are quite inexpensive and which make excellent substitutes for glass where full transparency is not demanded. Among these are cellophane, which is made by coagulating cellulose in a solution of viscose by means of a salt of ammonia, and cellite which dissolves in acetic acid and gives with camphor a mass which resembles celluloid. Other substances proposed are gelatine, which has been dissolved and then dried in sheets of the size required, and various products derived from casein and albuminoid bodies, such as bakelite; again, we may employ synthetic resin, which is prepared by the condensation of the phenols under the influence of formol.

One cheap substitute is unbleached cotton cloth which has been oiled; this however, is not very transparent and it is permeable by air so that at the end of a short time the alteration in color caused by the atmosphere gives it an unpleasant and dirty aspect, to say nothing of the fact that it is extremely inflammable. Much better than this is the exhibit offered under the name "P. A. T.," formed of two sheets of paper which adhere closely but are strengthened by the interposition between them of stout strands of hemp; translucency is imparted by a special sort of glue which unites the two sheets, and by a flexible varnish covering the exterior; the varnish and the glue make the finished pane entirely impermeable by water. This product is offered at a very low price.

So-called "Vitro-Cellose," which is insoluble in water and impervious to atmospheric attack, is composed of an extremely fine and light metal lattice work covered with a substance which is neither inflammable nor explosive, as is celluloid. This sort of pane can be set in windows like glass either by mouldings or by means of putty. The price in France is 16.5 francs ($3.30) per square meter. Another substitute offered is "flexible glass," constituted like the preceding by a product which is translucent and impervious to both air and water combined with an openwork support (tarlatan, muslin, gauze, fine light metal cloth, etc.), the whole then being covered with an even and flexible film. This kind of pane is exceedingly flexible so that it can be rolled up when it is to be transported; it is put in position in window sashes by means of strips of wood tacked in. This is sold, when the support consists of tulle, at 5 francs ($1.00) per square meter, and for 12.5 francs ($2.50) per square meter when the support is metal textile, the latter being, of course, much stronger as well as more expensive.

The Home in India

IN *Folklore* (Vol. XXIX, No. 2), Mr. W. Crooke contributes a paper on "The Home in India from the Point of View of Sociology and Folklore." The evolution of the form of the house, which in Western societies is often obscure, can be effectively examined among the castes and races of the Indian Empire, more or less completely isolated by distinctions of race and belief. The various forms assumed by the houses in India are fully described. One of the most primitive is that of the round house, of which there are some survivals, often in the form of churches in Europe, derived from the habit of bending down the pliant branches of some tree like the bamboo to form a temporary shelter. This also accounts for the curvilinear form of the Buddhist stupa, or receptacle for relics. The great pillared halls of the Mogul palaces are similarly derived from the reception pavilions of Central Asia. The occupation of a house marking a crisis in social life, a *rite de passage*, as Continental anthropologists describe it, gives rise to numerous taboos and precautions in order to disperse the evil spirits which occupy the site. The site selection, the laying of the foundation-stone, and the erection of the roof-beams are in the same way regulated by elaborate ceremonies. One curious phase is when a man, acting as a "scapegoat," is sent into the house before the owners occupy it, in order to take on himself the dangers to which they would otherwise be exposed.—*Nature.*

Method of Staining to Distinguish Between Bleached and Unbleached Sulphite Pulps

THE fibres are first stained with Cross and Bevan's ferric ferricyanide reagent which colors unbleached sulphite green on account of contained lignin, leaving the bleached pulp colorless. The contrast is further increased by subsequently staining with a red substantive dyestuff, when the green changes to a very pure blue and the bleached fibres are colored red. The ferricyanide reagent is produced by mixing equal volumes of $N/10$ ferric chloride and $N/10$ potassium ferricyanide. The slide carrying the fibres is dipped into this mixture for 15 minutes at 35° C. The red stain is prepared by stirring slowly into hot distilled water 0.4 grm. of Benzopurpurin 4 B. extra and 0.1 grm. of Oxamine Brilliant Red B. X. Immersion lasts 5 minutes. Fresh solutions are used.—*Note in J. Soc. Chem. Ind. on an article by C. G. Bright, in Tech. Assn. Pulp and Paper Ind.*

Electric Power Diagrams*

Annual Load Relief Map, Peak Load and Load Factor Analysis

By Wm. LeRoy Robertson

THE familiar daily load diagram is plotted by practically all electric light and power companies. The accumulation of these curves soon becomes a mere record, usually filed away in some manner and always available for reference, and for the study of local conditions. When considering the load throughout the year it is difficult to obtain a comprehensive idea of the whole since it is necessary to glance separately at the greater portion of 365 sheets. Such a record locks up a desired vision in confusion.

The Annual Load Relief Map is a device for visualizing the entire load of the year. Each daily load diagram is marked off on card board and cut out. The cards are stacked up in proper daily sequence, mounted and provided with graduations for kilowatts, hours of the day and months of the year, all properly arranged. The annual load relief map is illustrated in Figs. 1, 2, and 7, showing the Philadelphia load during the year 1916.

Day Load. A distinctive feature brought out by the annual load relief map is the contour of the day load which is consistently uniform throughout the year, always picking up between 7:00 to 8:00 a. m., having a valley at noon and then falling off punctually at about 5:00 p. m. This stands out clearly on the annual load relief map, Fig. 2; and especially well, if one will imagine the absence of the night load where it overlaps the day load at 5:00 p. m. The day load corresponds closely to the regular average working day.

Night Load. The night load which picks up rapidly at 8:00 p. m. in mid-summer, and at about 4:30 p. m. to 5:00 p. m. in winter, corresponds closely to the lighting load. It depends absolutely upon the hour of sunset for its beginning and falls off rapidly, shortly after reaching its peak value. After midnight, it settles down to a low value and drops off almost entirely when the street lighting goes off near sunrise. In summer a deep valley will be seen in the morning, (Fig. 2) between the "fall-off" of the night load and the beginning of the day load, while in winter the loads overlap in the morning, filling up this valley.

Peaks. During the summer months there are three distinct peaks—one occurring about 8:00 a. m.; one about 5:00 p. m.; and the third about 8:00 p. m. With the approaching fall and winter months, and as the sun sets earlier each day, the 8:00 p. m. peak moves back toward the 5:00 p. m. peak and near the end of September the two peaks overlap, giving a combined peak greatly exceeding any other peak, which rapidly increases in height until the middle or latter part of December, when it becomes the greatest peak of the year. As the spring months approach the combined peak diminishes and finally near the end of March, disintegrates, forming again the two separate peaks. While the above is a well known fact, the annual load relief map presents the changing condition in a most striking manner.

Daylight Saving. During the past year or more, twelve European countries have adopted the plan of setting the clock one hour ahead during the summer months, in order to utilize a greater amount of daylight. Nova Scotia on this continent has also adopted the plan. The cities of Detroit and Cleveland have practically accomplished the same thing by adopting Eastern Standard Time; and, further, the Committee on Daylight Saving of the Chamber of Commerce of the United States, in its report of February 1, 1917, recommended that Congress adopt the plan throughout the United States—advancing the clock on hour throughout the year; and, as an alternative plan, advancing the clock one hour during summer only.

The annual load relief map will be found useful in conjunction with the study of the effect of daylight saving on peak loads. Advancing the clock will have the same effect as shifting the day load back from the night load. Looking at Fig. 2, it will be seen that by shifting back the day load the valley between the 5:00 p. m. and 8:00 p. m. peaks will extend over a longer period during the summer; and if shifted back sufficiently, this valley will extend over the entire year, thus causing the big peak to disintegrate into the two separate peaks, eliminating entirely the big peak.

In order to entirely eliminate the big peak in Philadelphia, it is estimated that the clock should be set forward one and one-half hours. Fig. 3 illustrates what might have been the effect on the peak load in Philadelphia, had daylight saving been adopted during 1916. It should be understood, however, that these curves are merely a rough prediction, as it would be impossible to attempt to forecast the actual result.

The shifting back of the day load would also cause it to overlap the early morning load to a greater extent. This would increase the morning peak at 8:00 a. m.; but as the morning load is small, the increase would not be great. However, should winter office hours begin before daylight then the morning peak would obtain greater proportion.

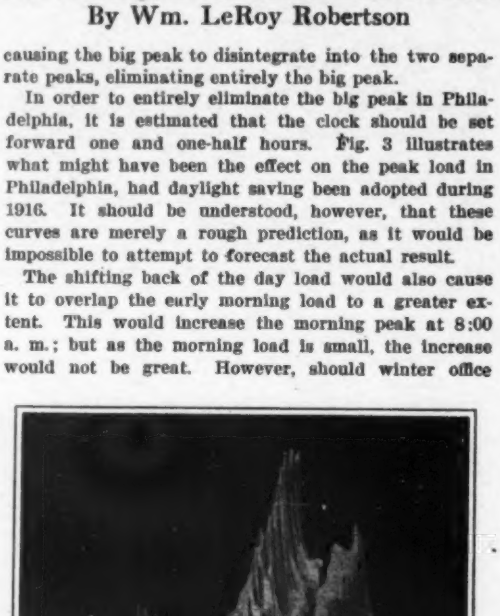

Fig. 1

Fig 2

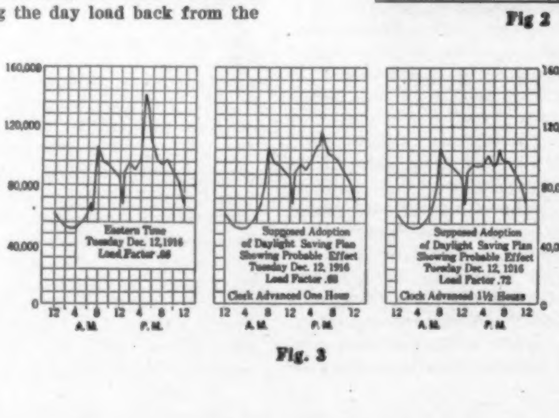

Fig. 3

Fig. 4 shows the effect of daylight saving on peak loads in Cleveland, while Fig. 5 shows the effect in Detroit. Cleveland's peak has greatly reduced, and it will be noted that the load factor has materially improved. In Detroit, it is understood that the radical change in the peak load has also been effected by other conditions than that of adopting Eastern Standard Time, *i. e.*, the load has greatly increased and all gem lamps have been changed over to Mazdas, during this period. The load curves given in Figs. 4 and 5 were furnished through the courtesy of the Cleveland Electric Illuminating Co. and the Detroit Edison Company, respectively.

Base and Top Loads—Load Factors. The total load on any central station may be divided into two sections as follows: Base load; top load. The sum of which equals the annual peak load, and the dividing line being a matter of judgment, as illustrated in Fig. 6.

After assuming any dividing line between the base and the top sections of the load, the annual load factor for the base section and the annual load factor for the top section may be computed from the 365 daily load curves covering the year in question. For a given annual load factor of the total load, the computed load factors of the base and top sections will not vary greatly between various central stations, as all central stations have very similar load diagrams and considerable variation in the individual load diagram may take place before the load factors are affected.

By examining the annual load relief map, it will be noted that the empty void between the contour of the load and a horizontal plane placed at the tip of the highest peak represents the business that a central station can theoretically carry along with its present business without increasing its equipment. If the central station load factor is 33 per cent, then this void represents 200 per cent of the business already carried. In cutting out the cards of an annual load relief map, if the upper half of the card is saved and stacked up, the mass of cards will represent the additional business that could be carried in theory by a central station without increasing the capacity. Fig. 7 represents the upper part of the annual load relief map. Here it will be noted that all the Saturdays and Sundays were separated and stacked separately at one end, in order not to hide the effect of the week days.

After the author devised the annual load relief map, it was learned that Mr. H. A. Barre of the Pacific Light & Power Corporation of Los Angeles, California, has been making use of practically the same scheme for the past several years. In connection with certain analysis of the relative values of water power and steam reserve, Mr. Barre found use for such a device in order to explain to the banker's satisfaction how much power would be carried by the water power, and how much by the steam reserve. At first, he experimented with a cube of wood, sawing along the line of the daily and yearly contours of the load which were respectively laid out on the faces of the cube at right angles, and later he stacked up the cards. Fig. 8 is a photograph, which was very kindly furnished by Mr. Barre, showing his plan. Each diagram is cut out in paper and placed in the file—5 years would be 7 to 8 in. (17.7 to 20.3 cm.) thick.

It might be suggested that commercial men may find much interest in following up the load growth from year to year upon the annual load relief map, and again the device may be useful as an aid in explaining various problems in connection with rates and investment before public service commissions.

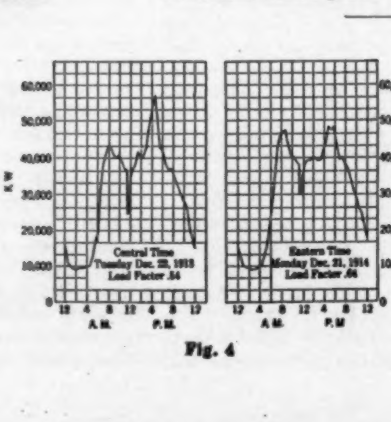

Fig. 4

*From proceedings of the Am. Inst. of Electrical Engineers.

Mexican Nettle as a Fiber Plant

EXPERIMENTS are being made in the cultivation of the Mexico nettle, the fiber from which has been found to be well suited for the manufacture of various textile fabrics. At the Museum in Mexico City is an exhibit of the plant from growth to utilization.

Instruments for Air Use*

Let us take a look into an airman's office. I do not refer to the wooden hut on the ground where in bad weather cigarettes are smoked, the illustrated weekly papers read, and aerial operations discussed in professional slang.

I mean the "office" where the pilot does his real work; and this is the name which for some inexplicable reason has been given to the cockpit of an aeroplane, wherein sits the aviator. To the uninitiated it appears a confused medley of dials, recording needles and levers; mysterious, unfathomable, exciting. But to the trained airman these things are as an open book; and each one of them is in some way essential to the control of the machine and its manœuvres.

The most important of the instruments is the compass. Without its aid an airman who is flying over the sea or over land on a misty day is hopelessly lost. In the R. A. F. great attention is attached to the necessity for every pilot being able to fly a compass course; that is to say, a course along which he is guided solely by his compass; and very great progress has been made in this connection. Thousands of miles are flown every week on patrols over the sea alone, and pilots nowadays very rarely come to grief through losing their way.

This is saying a good deal, when the problem presented by drift is remembered. If an aircraft starts from one point to fly to another due East, and there is a wind blowing at 15 miles an hour North-East, that will clearly have to be taken into consideration, and the compass course altered (before ascending) according to the total distance of the journey.

Many difficulties had to be overcome in the production of a satisfactory compass for aerial work. Chief among these was that of neutralizing the magnetism of the engine (and in particular the magneto) and of preventing the effect of centrifugal force, which caused the card or dial inside the compass to swing in a direction quite independent of North when the aeroplane was banking on a turn. However, a truly excellent compass is now in use in the R. A. F., far superior to that employed by the enemy. And indeed it would be odd if the Germans should have proved able successfully to compete in this direction with a nation whose commerce for several hundred years has been largely dependent on the excellence of its ships' compasses.

Probably the next most important instrument is the aneroid or height indicator. This is worked on a simple mercury principle, and is generally fitted with an adjustable dial which can be moved round so that the reading on leaving any given aerodrome is zero. Which reminds one of rather an amusing occurrence. A pilot left his aerodrome for a cross country flight on a very misty day, and carefully set his aneroid to 0. After flying for a couple of hours by compass he thought he must be nearing his destination. He could see nothing below him and so descended to 500 ft. On he flew at this height for another five minutes. Deciding to land, he was about to make a magnificent volplane, when suddenly the mist cleared and he saw ground immediately underneath him, about 10 ft. below. His faithful aneroid still insisted that he was 500 ft. high. The explanation lay in the fact that the place he was about to land on was 500 ft. higher above sea level than the aerodrome when he set out. Trifles like this are all in the day's work and help to teach the young pilot never to become the slave or dependent of mere instruments.

Next we have the tachometer or "rev. counter," which records the number of revolutions the engine is making per minute. This varies from about 1,100 (in rotary motors) up to 1,800 in water-cooled engines. The reading of this instrument is of great interest to the pilot, for modern aircraft are so carefully designed that their performance is effected enormously by even an extra 100 revolutions or so per minute one way or the other.

Another important instrument is the air speed indicator. This tells the pilot at what rate he is rushing through the air. This speed, of course, has no relation to the rate at which he is travelling over the ground. Nor is it intended to, for it is air speed which is of importance to the stability of the aircraft and the safety of the pilot. If a machine flying at 70 miles per hour is travelling against a 40-mile wind, the A. S. indicator will show a 110 m.p.h.

Every aeroplane has a minimum air speed at which it must be thrust through the air if it is to be maintained aloft; and a maximum air speed in excess of which it cannot safely be nose-dived, for the various components will not stand the strain beyond a certain given point. It can be seen how essential is this device on a flying machine. Air speed indicators have been fitted to British aircraft for years past and it is interesting to note that the Germans have just commenced to use them.

The next item which calls for attention is the inclinometer. This is a curved spirit level fitted transversely across the machine. It is marked in degrees; and the pilot can tell from it at what angle he is banking his craft when turning.

With the addition of a miniature set of electric light clusters and a neat eight-day watch the list of instrumental equipment is concluded. The only remarkable feature of the watch is that if an aeroplane is left without a guard for five minutes after a forced landing, the watch mysteriously disappears!

There are several pressure gauges on the dashboard. One for each petrol tank, to indicate the pressure at which air is forcing the spirit to the engine; and another one to show the pressure in lbs. to the square inch at which oil is being driven through the various lubrication channels. On water-cooled engines a thermometer records the temperature of the water in the radiator.

Space forbids a detailed description of the controls. However, it may briefly be said that there is a swivelling foot-bar for the rudder; while a central lever, commonly known as the "joystick" actuates the elevation and banking of the aeroplane. A wheel at the side increases the angle at which the tail plane "attacks" the air, this being for rapid ascension. Two side levers control the speed and petrol consumption of the engine.

Then come the various articles of military equipment. These comprise the machine guns with their actuating gear firing straight through the propeller, and controlled by a lever on the joystick; the wireless outfit in the observer's cockpit; and, finally, message bags, bomb sights, and camera release handles.

And some folk seem to think pilots are not very busy people!—*From Flight.*

* By Lieutenant William A. Robson, R.A.F., Author of "Aircraft in War and Peace."

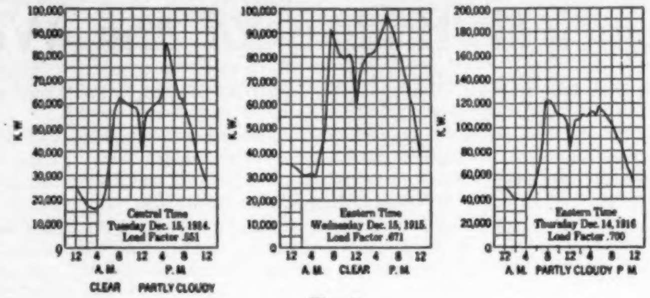

Fig. 5

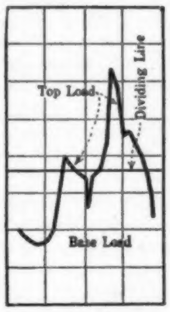

Fig. 6

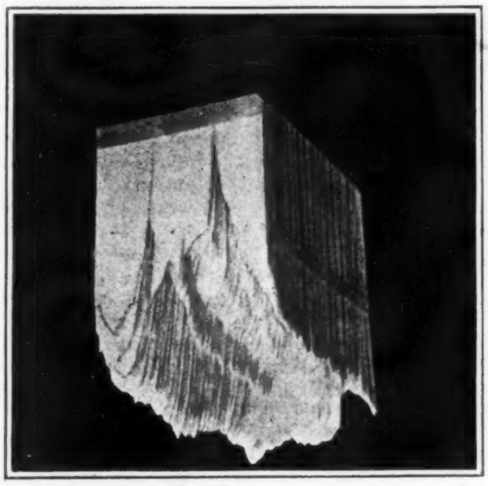

Fig. 7

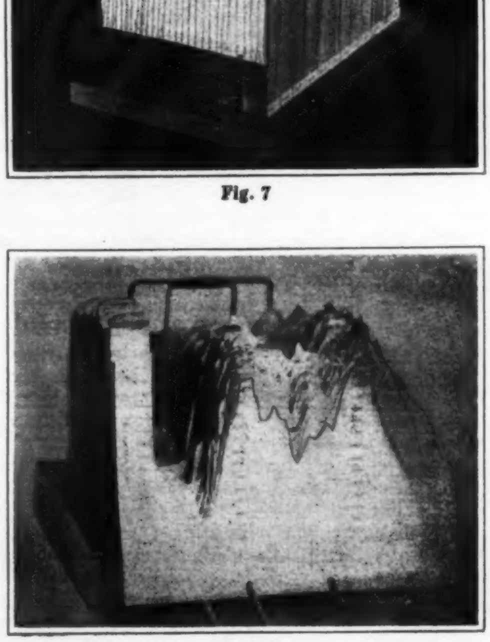

Fig. 8

Substitutes for Coal in Gas Making

Various substitutes for coal, and the methods of using them as applied in gas works in France and Switzerland, are described. At Geneva, sawdust is added to the extent of 10 per cent to the normal charge of coal in Bueb vertical retorts. As an alternative, logs of wood, 3 feet in length, are used, the charge then being 260 pounds as against 1,240 pounds of coal. Wood and coal are worked alternately on two benches, with the result that the tars produced are not acid. The furnaces consume 20 per cent more fuel than normally; the yield of gas is 8,570 to 8,830 cubic feet per ton and the wood gas is not separated from the coal gas. At another Swiss works (La Chaux-de-Fonds, Neuchatel) sawdust is carbonized in horizontal retorts, 375 pounds of sawdust being mixed with 66 pounds of coal, against a previous coal charge of 990 pounds. The carbonizing period in retorts of 14 feet, 8 inches is six hours. The calorific power of the gas is 4,200 calories and the high proportion of water in the tar (30 per cent) has given trouble. At Neuchatel, wood is used to the extent of 28 per cent of the coal. Horizontal retorts 9 feet 6 inches in length are used, charges of 150 to 210 pounds being carbonized in 4 hours, giving 10,600 cubic feet of gas per ton of a calorific power averaging 4,300 calories. The use of wood leads to the removal of carbon deposit and to a porous condition of the refractory, hence coal and wood are used alternately. Acid products from wood have caused some corrosion, and lime is required in purification. In France (Arcachon, Gironde) heath roots have been used, giving a yield of 23.78 per cent of gas and 22.84 per cent of charcoal. With a charge of 130 to 165 pounds the carbonizing period is 2½ hours. The charcoal is superior to pine charcoal and the quality of the gas is satisfactory. At Royal (Clarente Inferieure), a cargo of spoilt flour has been used, giving 11,300 cubic feet of gas and 1,600 pounds of coke from 1 ton 7 cwt. of flour. The coke was of good quality with scarcely any ash.—*Note in J. Soc. Chem. Ind. on an article by B. Tollens in Z. angew. Chem.*

New Aluminum Alloy

According to the Queensland *Mining Journal* aluminum alloyed with 10 per cent of calcium makes a metal of superior qualities, lighter than aluminum. These castings machine well, are free from brittleness, and take the minutest impressions of the mould. Alloys of copper, tin, or zinc with aluminum are less resistant to corrosion. The calcium also neutralizes the tendency of the aluminum to oxidize. It does not decompose in water and can be remelted as readily as pure aluminum.

The Principal Bridges of the World—I

A Comparison of Their Size, Importance and Principles of Design

We have heard that the American bridges are the "biggest on earth," and some of them are certainly of enormous dimensions, but if the principal bridges of other countries are placed with them on a drawing side by side and to the same scale, the relative importance of some of them will appear not quite so overpowering as to justify such a claim.

CANTILEVER BRIDGES

Forth Bridge.—The bridge at Queensferry over the Firth of Forth is admitted to be the largest cantilever bridge yet built. There are two spans of 1710 ft. each, with central suspended spans of 350 ft. resting on cantilevers having 680 ft. projection and two anchor arms outside them of 690 ft. each. These dimensions, with the towers, make the total length of main structure 5330 ft.

The trusses are not in parallel planes, but are inclined inwards one to the other, being 120 ft. apart at the piers and only 31 ft. 6 in. at the ends. Most of the compression members are hollow tubes, of a maximum diameter of 12 ft. The whole structure consists of 51,000 tons of steel, and carries two lines of rails. The total length of the viaduct, including the approach spans, is 8,095 ft., and the clear headway at high water is 150 ft.

Critics have said that the suspended spans are about half as long as they should be for both appearance and economy; that the span should have been pin connected, both for ease of erection and for stress certainty; that a single system of web diagonals would have been more scientific than the double system adopted; and the design unnecessarily expensive.

One reply to these remarks is that the British system of bridge design is altogether more substantial than those of America and some other countries, and that the pin system is not cared for here. At all events, the bridge is still standing and has not failed like some other ambitious structures.

For the sake of comparison with the length of the Forth bridge, may be mentioned the Tay bridge as re-erected 1882-1887—see later. The overall length in this case is 10,711 ft., the number of spans is seventy-four, eleven of them being of 245 ft. and two of 227 ft.

The Quebec bridge has often been held up in comparison with the Forth bridge as having a greater span, and while this is certainly the case, yet placing the two diagrams together, the fact can easily be noted that the one bridge has two spans, while the other bridge has only one, and that the English example is nearly double the length of the other.

Britannia Bridge.—The Britannia bridge over the Menai Straits, was built in 1845-1850, at a time when wrought iron bridge work first came into use. It may not be properly described as a cantilever bridge, being in fact a continuous girder design, but the bridge is nearer the cantilever type of structure than it is to the simple girder type of design. These are two spans of 460 ft., and two spans of 230 ft., the overall length with the portions over the intermediate piers and end supports being 1511 ft. Each span consists of two separate tubes, both the top and bottom flanges or chords being made up of cellular construction. The total weight of metal in the bridge is 4306 tons.

The two central spans were floated out to their place on pontoons, and the two short spans were erected on timber false-work, but the whole of the erection was arranged in such a manner that an initial stress was set up in all parts of the girder, with the view of making the girders in a true sense continuous.

Blackwell's Island Bridge.—The Blackwell's Island bridge over the East River near New York City has the next longest span to the Forth bridge. There are five openings, a central span of 630 ft., two spans, one on each side of 1182 ft. and 984 ft. respectively, and two anchor arms, at the ends, of 469 ft. 6 in. and 459 ft., thus making a total overall length of 3724 ft. 6 in. This bridge has been criticised for its alleged false and objectionable lines, and for the omission of suspended spans in the wider openings, an arrangement which is said to produce very complicated stresses in the structure. It is also said that the omission of inclined struts was a mistake, as the compression is thus not in any way divided, and, lastly, that the dead loads in the structure were much underestimated. As a matter of fact, some of the roadways the bridge was intended to carry were not put in. The two larger openings, having the girders connected at the centre without a suspended span, made the stresses indeterminate.

The girders are 60 ft. apart on centres, and were intended to support on the lower deck a central carriage-way with two car tracks on each side, the outer tracks being on an extension of the floor beams cantilevered outside the girders, making the lower deck 86 ft. in width. The upper platform was intended to carry four tracks for the elevated tramway between the girders, with a promenade or footway outside the the girders, also cantilevered out. Nickel steel was used for the tension members and the pins. Perhaps this is the longest cantilevered span in the United States.

Quebec Bridge.—The latest competitor to the Forth bridge is the new Quebec bridge, built to replace the first structure at this place, which fell down in 1907, owing to the crippling of a compression member in the bottom chord. The new design provides a central span of 1800 ft. instead of 1758 ft., as in the earlier bridge, this dimension being made up of two cantilevers, each 580 ft. projection, and a suspended span of 640 ft. There are two anchor arms outside the supporting piers of 515 ft. length each, making the overall length of the bridge 2830 ft. The trusses are 88 ft. apart, and the weight of metal in the new bridge is 65,000 tons, instead of 35,000 tons, as in the original bridge.

The proportionate length of the suspended span is 34 per cent. of the main opening, in close accord with the economic percentage of 38, as determined by J. A. L. Waddell for such a case. This is a greater proportionate length than in the Forth bridge, which has been criticised in this particular.

The K system of trussing the web, as compared with the double system of bracing of the Forth bridge, is here shown to perfection; the floor beams are hinged at the ends for the purpose of placing the loads exactly central on the main trusses and the consequent avoidance of secondary stresses; lateral bracing in the top chords is omitted with the idea of throwing the wind resistance wholly upon the bottom chord, and the eyebars are trussed to support their weight between the main supporting points.

It is claimed that the K system of trussing the main web gives greater safety during erection and more economy and rapidity in construction, as fewer temporary members are required. It also simplifies the details and reduces the sections of the diagonal bars, at the same time much reducing the secondary stresses.

Thebes Bridge.—The Thebes bridge carries the railway over the Mississippi in Illinois. The design consists of five spans, two of which, the second and fourth, are 521 ft. 2 in. long, and are provided with simple girders having cantilevers at each end over the central and end spans of 152 ft. 6 in. projection. Each end span is made up of this cantiliver projection and a suspended span of 366 ft., making a span of 518 ft. 6 in. and the central span is made up of two of the cantilever arms with a suspended span also 366 ft. long, making the third or central span 671 ft. in length. The bridge is thus perfectly symmetrical about its central point. From the æsthetical point of view this symmetry is pleasing, but the criticism is made that the structure as a whole is too squat for a fine appearance, and that it would have been an improvement had there been five simple spans, all but the middle one being alike, and even this span could have been made simply an enlargement of the others. The bridge is for two lines of railway, and the trusses are 32 ft. apart on centres. All are pin connected. The weight of steel in the bridge is 12,000 tons, and the total length of the structure is 2750 ft. 4 in. without the approaches.

Poughkeepsie Bridge.—The Poughkeepsie bridge over the Hudson River consists of five spans and two anchor arms. The second and fourth spans are covered by simple lattice girders 525 ft. long, from which cantilever arms are carried out over the first, fifth, and the central spans, to carry suspended spans. The two end spans are each 548 ft. long, and the central span 546 ft. Outside the end span are anchor arms each 201 feet in length, fastened down at the extreme ends. The piers are formed of steel braced legs resting upon masonry, the top of which is a few feet above the water level.

The criticism has been made that in this case also it would have been more economical to have made all the spans alike and without the cantilever and anchor arms, which were designed at the time when cantilever bridges were fashionable, and perhaps assumed to have some inherent value not now apparent.

The bridge was originally built for a double line of railway, and has been strengthened by inserting another line of trusses midway between the original girders, and adding new columns in the towers supporting the bridge. This reinforcing alone employed 15,000 tons of steel. The whole length of the seven spans is divided into 95 equal panels of 31 ft. 9⅝ in., and the overall length is 3093 ft. 9 in.

Cernavoda Bridge.—The Cernavoda bridge over the Danube in Roumania, like the Thebes and the Poughkeepsie bridges, consists essentially of five spans, the second and fourth spans being simple girders with cantilever at each end projecting into the adjoining spans, the rest of the structure being made up of suspended spans.

Here the second and fourth spans have a length of 459 ft. 3 in., the central span is 623 ft., and the two end spans 459 ft. 3 in. long. The length of the four cantilever projections is in each case 164 ft., and although the points over the piers have a somewhat unpleasant appearance, the perfect symmetry of the whole is satisfactory to the eye. The lattice bars forming the web of girders and cantilevers are of the double intersection type, and in this respect are quite different from the American bridges given in the sketches.

Memphis Bridge.—The Memphis new bridge over the Mississippi River is noted for the irregularity of its spans, which vary from 347 ft. to 790 ft. 5¼ in. One span of 621 ft. has a simple lattice girder with cantilever arms projecting 186 ft. 3¾ in. over adjoining spans. At one end of the longest span is a cantilever of the same length as the others, balanced by an anchor arm of similar length, firmly held down at the pier. The two suspended spans have a length of 417 ft. 9⅜ in. All the joints are pin connected, eyebars are used for tension members, while compression members have the form of channel or double tees.

This structure is criticised as being both unsightly, uneconomical of material, its lay out of spans unfortunate, and its truss depth too small. The spans were, however, laid out to meet the desires of the War Department. There is no symmetry about the design, and it is not happy to have one end of the structure formed into an anchor arm of the through type and the other end as a deck span below the level of all the other openings.

The bridge carries a highway and a single line of railway, the two lines of trusses being 30 ft. apart, and the weight of steel employeed in the structure was 8,160 tons, the length overall being 2548 ft. 10½ in.

Landsdowne Bridge.—The Landsdowne bridge over the Indus River at Sukkur, in India, consists of a single span of 820 ft., this dimension being made up of two cantilevers of 310 ft. each and a suspended span of 200 ft. The anchor arms of other bridges are here replaced by guys anchored back from the top of the piers into the ground at each end of the bridge. The criticism has been made that the design is "bizarre in the extreme," whatever that may mean, and that the structure is economic in neither weight of material nor cost of shopwork. But in any case the design is workmanlike, and shows the principle of its design much better than many American bridges, where the principle of cantilevering out to a central suspended span has to be sought out of its camouflage with some trouble and frequently cannot be seen at a first glance.

It is supposed that a considerable part of the cost of this bridge was caused through the complete erection of it temporarily in the shops in England before shipping to India.

Red Rock Bridge.—This hiding of the principle of cantilever and suspension may be evidenced in the case of the Red Rock bridge over the Colorado River, on the Atlantic and Pacific Railway, now part of the Santa Fé system. This bridge consists of one span of 660 ft., made up of two anchor arms of 165 ft. each, and a suspended span of 330 ft. Anchor arms of 165 ft. length are provided at each end beyond the main span, making a total length of 990 ft. The truss depth varies from 55 ft. to 101 ft. over the vertical posts at the piers. It is said that the subject of æsthetics did not receive great consideration in this bridge, and that architects are divided in their opinion as to whether the outline is pleasing, or, on the other hand, is harsh.

The design has been remodelled since the bridge was constructed 28 years ago, the live loads being found to be 75 per cent. greater than they were when the original design was made. The bridge carries one line of railway, and contains 750 tons of steel. The shape of the cantilever and anchor arms is very remarkable, being similar to a bird without a head. The anchor arms are

* *The Engineer.*

securely held down at the piers, and all the joints are pin connected.

Connel Ferry Bridge.—The Connel Ferry bridge carries the Callender and Oban Railway across Loch Etive in Scotland.

The span is 524 ft. between the centres of the piers, and the remarkable feature is that the member supporting the cantilever arm is not vertical over the pier, but is inclined at such an angle that the cantilevers are each reduced to a length of 92 ft. 3 in. The suspended span is 232 ft. in length, and the anchor arms on each side of the main span are each 105 ft. 7 in. in length beyond the supporting piers.

The criticism has been made that while the symmetry of the structure is perfect and gratifying, yet the lines are too severe for beauty, and that the economies of the design are questionable. The large triangular frames supporting the bridge are certainty of bold design. This bridge is the second largest span cantilever bridge in Great Britain, and the current was so strong in the centre of the river that it was considered not practicable to build a central pier. One line of railway is accommodated.

STEEL VIADUCTS.

Lethbridge Viaduct.—The Lethbridge viaduct is probably the largest and heaviest viaduct in the world of this design, and has 12,200 tons of steel in its structure, a length of 5327 ft. and a maximum height of 314 ft. It is situated on the Canadian Pacific Railway over the Bow River and valley in Alberta, Canada. The design, except one span, consists of piers of 67 ft. width with simple girders between them of 100 ft. span, all these being of the plate girder type. The half-through form of construction was adopted throughout, with the view of preventing the trains running off the viaduct in case of derailment. The girders are 8 ft. deep and 16 ft. apart on centres. The towers are made up of horizontal members and diagonal struts. The erection was done by a steel traveller weighing 356 tons. The columns are 26 in. square and were built up of angles and plates.

Boone Viaduct.—The Boone viaduct is claimed to be the largest double-track viaduct in the world, is 2685 ft. in length, and carries the Chicago and Northwestern Railway over the Des Moines River. The towers are 18 in number, 45 ft. in width, and the maximum height is 185 ft. Stiff diagonal bracing is provided throughout without horizontal members, excepting at the foot of the towers. Each of the steel verticals is made up of two 20 in. beams and one 15 in. beam. The spans are 75 ft. each, with one exception of 300 ft., and all the girders except the larger span have a uniform depth of 7 ft., there being four lines of main girders at this depth.

Portage Viaduct.—The Portage viaduct, over the Genesee River, was one of the most notable of the early viaducts, and was originally 876 ft. long, with timber Howe trusses 14 ft. deep on timber towers, the uprights of the towers being connected by horizontal girths 40 ft. apart vertically, the whole supposed to be the boldest timber bridge ever erected. Burned down in 1875, it was immediately replaced in metal. It was rebuilt again in 1903 so far as regards the deck, and now consists of four 50 ft. spans, six 50 ft. towers, two spans of 100 ft., and one span of 118 ft., the larger spans being of truss design.

Verrugas Viaduct.—The Verrugas viaduct carries the Lima and Oroya railroad over a gorge in the Cordilleras, about 50 miles from Lima, in Peru. The viaduct consists of three trestles or towers, each 50 ft. wide, and made up of six verticals braced together, the height being 256 ft. above water level, and the trestles themselves being respectively 145 ft., 252 ft., and 178 ft. in height. The spans between the towers are four in number, three of them being of 100 ft. span and one of 125 ft. The Fink system of trussing was adopted. The overall length of the viaduct was 575 ft. It is said that this viaduct was the first large one built of wrought iron in America. It collapsed in 1889, and was replaced by a three-span cantilever bridge, and the centre and highest tower was omitted from the new design.

Lyon Brook Viaduct.—The Lyon Brook viaduct is a very old type, being built in 1869, and one of the earliest metal bridges. It carries the New York, Oswego and Midland Railway, and is 820 ft. long. It consists of a series of wrought iron trestles 30 ft. apart, making 24 spans of this dimension and one larger trussed span of 100 ft. Wood was employed for several of the continuous lines, on account of there being less to fear from expansion and contraction, but wrought iron ties were used. The large span trusses were carried on trestles entirely constructed of iron.

Pecos Viaduct.—The Pecos viaduct was built in 1891, is on the Southern Pacific Railway between San Francisco and New Orleans, and is situated over the Pecos River, a tributary of the Rio Grande in Texas. It is one of the longest viaducts in America. It was originally constructed in 46 spans, 32 of these spans were of 35 ft., two of 35 ft. 3 in., one of 45 ft., eight of 65 ft. Two pin connected cantilever trusses and anchor arms of 172 ft. 6 inch. length and one 80 ft. suspended span, the overall dimensions being 2180 ft.

It was constructed for a single line, and was strengthened in 1910 by the addition of another and centre line of girders supported on new cross girders between the legs of the towers, and at one end 19 spans were then removed and replaced by an embankment. One of the features of this viaduct is the central cantilever opening of 185 ft. clear, and two anchor arms on each side of this of 85 ft. length. The erection was done by means of a nine-ton traveler, which was used for both towers and girders until the cantilevered trusses were reached. This part of the erection was carried on by building out from each side until the centre was reached. The capacity of the traveller was arranged to suit the 65 ft. lattice girders.

Free Bridge, St. Louis.—The Free bridge over the Mississippi at St. Louis is one of the longest span simple truss bridges yet constructed. The trusses are of the "Petit" type and are three spans in number, the span being 668 ft. in each case. The design is altogether different from the other cases of trestles and simple girders, and the spans of much greater length. A considerable weight of nickel steel was used in these spans. This bridge carries a railway line, and above this the highway.

Runcorn Viaduct.—The Runcorn bridge, over the river Mersey, was commenced in 1863, and carries the London and North-Western Railway, and a narrow footway, by three spans, each 305 ft. 9 in. clear. The entire viaduct consists of 101 openings chiefly of brick arches. There is a clearance of 75 ft. above the high water line, and the Manchester Ship Canal was made to pass under one of the spans. The bridge was constructed at so early a date that the lattice bars were placed close together, no articulation of the truss being attempted.

Tay Viaduct.—The Tay viaduct, near Dundee, was reconstructed after the accident in December, 1879, when the ironwork of 12 intermediate piers and 13 girder spans were carried away during a storm of exceptional severity. The viaduct as reconstructed is 10,711 ft. in length, and is therefore nearly double the length of the Canadian Lethbridge viaduct. The spans are not all of the same length, the eleven larger spans being each 245 ft. 6 in. There are also two of the same design, but of 227 ft. The other spans are mostly of straight lattice girder design from 66 ft. to 118 ft. spans, the clear headway being mostly of 77 ft. height at high water of spring tides.

Saltash Bridge.—The Saltash bridge carries the Great Western Railway over the river Tamar near Plymouth, and was designed by the eminent early engineer, I. K. Brunel, in 1859. It is of the "Lenticular" type, the girders consisting of lens-shaped trusses, the top chord consisting of a single large wrought iron elliptical tube, and the curved bottom chord being in the form of a stretched chain, the two chords being connected together by open truss bracing. There are two spans, each of 455 ft., and in addition to them there are 17 smaller spans of 69 ft. 3 in., making a total length of viaduct of 2240 ft., the overall length thus being greater than the Pecos viaduct, and less than the Boone viaduct. Each main truss was made completely on the shore and floated out to its position, being then raised by jacks. The central piers are of circular masonry, 35 ft. diameter and 96 ft. high, the side spans being of double masonry 11 ft. square. The rails are 100 ft. above high water.

ARCH BRIDGES

Niagara Clifton Bridge.—This bridge is 1000 ft. below the Falls, and has a central span of 840 ft., with two much smaller approach spans, and, until recently, was the longest arch span in existence. It has a rib of constant depth, the chords being 26 ft. apart. Two pin-bearings or hinges are provided, one at each end, and the end panels of the ribs are tapered down to a point at the hinges.

The two-hinge arrangement is somewhat unusual in America. It is said not to be anything like as rigid as the arch without hinges, or with only one pin in the centre. The temperature stresses of the two-hinge type are frequently considerable, especially in the case of flat arches, but are not so great as for the hingeless type of rib. The calculation of the stresses is very long and elaborate for the two-hinge type, but, again, is not so great as in hingeless structures. On the other hand, the one-hinge type is far easier in calculation, is fairly rigid, the temperature stresses are less, and slight movements at the bearings would not be so serious as in the case of the hingeless type.

The Niagara-Clifton bridge has a deck 46 ft. wide, with two electric railway lines in the centre, and a double carriageway, with footwalks on each side corbelled out. The floor is supported by a series of uprights, rising from the extrados of the great arch below. The two main ribs are 30 ft. apart at the centre or crown, but are built on planes sloping out at the bottom to 69 ft. The curve of the neutral axis is parabolic, and has a rise at the centre of 150 ft. The depth of water under the bridge is supposed to be about 180 ft. The erection was carried out on the cantilever method, advantage being taken of the then existing suspension bridge of 1858, until the arch ribs met in the centre, and the bridge was opened for traffic in August, 1898.

Viaur Viaduct.—This viaduct carries a single line of railway between Carmaux and Rodez, in France, the railway being 385 ft. above the valley below. The design, which is notably French in conception, consists of a central arch, 721 ft. 9½ in. span, and two cantilevers on each side, the side spans being 311 ft. 8 in. each, and the total length of the viaduct amounting to 1345 ft. 1½ in. between the abutments. The central span practically consists of two cantilevers, since there is a central pin in the middle of the span, and the side spans are made up of a cantilever arch of 228 ft. 4 in. projection, and a short span of 83 ft. 4 in. length, resting on the cantilever at one end and upon the stone abutment at the other end. There are also pins at the springings of the arches. A permanent walk and tramway are provided below the floor. All the compression members are thicker in the centre and the trusses are all riveted. The main arch ribs are 19 ft. 6 in. apart at the centre of the span, and slope out 1 in 4 to 109 ft. width at the springing, the steel work being thus constructed on two inclined planes.

This bridge was described at the International Railway Congress as having a special system of design which might be called that of 'balanced girders." Each girder is a kind of balance beam whose tendency is to incline towards the middle of the central span, where it is connected by means of a pivot to the other girder. Rigidity is obtained by means of a single system of web bracing, consisting of uprights and rigid diagonals, stiffened by a complete system of wind bracing.

The Bonn Bridge, built in 1898, over the Rhine, is the longest arch of its type in Europe, and has a central span 614 ft. long, being second only to the highway arch at Niagara.

In this case the trusses are in vertical planes, 29 ft. 6 in. apart, and the bridge carries a 23 ft. roadway and two footpaths, 11 ft. each in width, the footpaths being cantilevered out. The ribs of the arch vary in depth from 15 ft. at the centre to 34 ft. at the springing, the lower chord having a rise of 97 ft., and both chords being formed into a continuous curve. All the joints are riveted, and the erection was carried out from falsework. This bridge has two hinges. At each side of the central arch are two other arches of 307 ft. span.

The Dusseldorf Bridge, also over the Rhine, is of similar design to the bridge at Bonn, and was also completed in 1898. There are two central spans of 594 ft. 6 in. each, and smaller side spans of 198 ft. and 200 ft. 9 in. The bridge carries a roadway 27 ft. wide, and two side walks cantilevered out 62 ft. above the water. The arches are circular in shape, and have a rise of 90 ft. on the underside. The depth of the arch varies as in the Bonn bridge, being 16 ft. 6 in. in depth at the centre and 40 ft. at the ends. The trusses are 31 ft. 9 in. apart centres. These arches have also two hinges.

The Luiz I. Bridge, over the Douro, was built in 1885, and has a clear span of 566 ft. There are two roadways, one above the arch and one at the springing level. The higher roadway is 160 ft. above the lower road level. The position of the lower roadway was taken advantage of to provide a horizontal tie at this level, forming a very remarkable design. The ribs are 26 ft. deep at the crown, and are 20 ft. apart at this level, widening out to 52 ft. 6 in. at the spring. The lower roadway is formed by two lines of lattice girders, 10 ft. 6 in. deep and 29 ft. 6 in. apart, and is supported from the arch at four intermediate points.

The Pia Maria Bridge, over the same river, at Oporto, in Portugal, was built, in 1877, and at the time was considered to be one of the boldest metal arches in existence. The arch is crescent shaped, is supported on hinges at the ends, and is 33 ft. in depth at the centre. The ribs are built in inclined planes, sloping out from 13 ft. centres at the crown to 49 ft. at the hinges. The

rise of the lower chord is 123 ft., and at the crown is 200 feet above the water. A single line of railway passes over the arch at a height of 251 ft. above the water, and the arch was erected by the cantilever method without falsework. There are two approach spans at one end and three at the other end, each having a span of 94 ft.

The Kaiser Wilhelm Bridge, over the Wupper River, at Mungsten, in Prussia, is one of the largest in Europe, and was completed in 1896. It carries a double line of railway with foot-walks cantilevered out on each side, the rails being 350 ft. above the valley. The two main ribs are parabolic in shape, and have a span of 557 ft. 6 in., the two chords being 16 ft. apart at the crown, but this distance widens out to 83 ft. at the springing. The towers were erected from temporary wooden staging, and the large arch was cantilevered out from each side and anchored back to the other parts of the viaduct. Three hinge bearings were adopted when the arch was at first erected, but subsequently the hinges were removed and the whole made into a fixed construction, the arch being kept from moving by the weight of the metallic piers resting upon the bearings. It is now said to be the largest fixed end arch in Europe.

The Garabit arch, over the Truyere, near St. Flour, in the south of France, was built in 1885, and has a span of 540 ft. The deck is 406 ft. above the water level and the arch carries a single line of railway, and is said to be the highest iron arch in the world, with, perhaps, the exception of the St. Guistina arch, over Noce Schluchet, built in 1890, which is the highest bridge in existence, with its height of 460 feet above the valley below. An inspection footpath is carried underneath the floor of the bridge. The arch ribs are sickle or crescent shaped, the two chords being 33 ft. apart vertically at the crown, the two ribs being 20 ft. 6 in. apart horizontally at the top and 65 ft. 6 in. at the springing. The centre line of the arch is a parabola with a rise of 166 ft. in the lower chord, and the arch ribs are pivoted at the springings.

Part of the span of the large arch, about one-eighth, was erected on falsework, and the remainder cantilevered out from the other parts of the viaduct. For purposes of erection a temporary wooden bridge was constructed under the arch at a height of 100 ft. The towers were constructed with a batter of 1 in 25 longitudinally, and 1 in 8 1/3 transversely. The rails are carried on half-through lattice spans above the arches and piers, with the idea of keeping trains from running off the viaduct should they be derailed. Wrought iron was used throughout.

Bellows Falls Bridge, Connecticut.—The highway bridge over the Connecticut River, at Bellows Falls, was at one time said to be the longest arch span in America. It has a span of 540 ft., and was built in 1905. The arch rib is made up of parabolic chords, 14 ft. apart, and the highway carried by them is on an inclination of 1 in 33.

The St. Louis Bridge, over the Mississippi River, was the first steel arch, and the first and largest railway arch, in America. There are three arched spans, the central being 520 ft., and the two side spans 502 ft. each in length, the rise of the arches being 47 ft. and 44 ft. respectively. The bridge was completed in 1874. Each span has four segmental arch ribs, two to each line of railway, in vertical planes, and the chords are 12 ft. apart. The chords are made up of chrome steel tubes 16 in. diameter, each being formed of six separate staves bound together with steel plate hoops. They do not follow the general curve of the rib, but are in straight lengths of 12 ft. The arch ribs have fixed ends and no hinges, the ends being bolted down, and this bridge is said to be the longest arch without hinges. There are two separate decks, the upper deck being 54 ft. wide and used exclusively for carriage and pedestrian traffic. The lower deck has two lines of railway, and has 144 ft. clear height above the water in the centre of the bridge. The gradient forms a parabolic curve over the bridge.

The erection was carried out without falsework on the cantilever principle, equal weights being ensured on each side of the piers by fixing corresponding pieces symmetrically from the piers.

The Washington Bridge, across the Harlem River at New York, has two 510 ft. steel arch spans, and carries a 50 ft. roadway and two side footpaths, each 15 ft. wide. The deck is 141 ft. above water, with a clear height of 133 ft. The bridge was completed in 1889. The arch girders are six in number, and are plate arched girders, 13 ft. deep, spaced 14 ft. apart, with a rise of 92 ft.

The Zambesi Arch Bridge, built in 1905, is of 500 ft. span, with approach lattice girders on each side. There are two spandril braced arch ribs, the bottom chord being formed to a parabolic curve. The ribs are 27 ft. 6 in. apart at the top, but are built on a batter of 1 in 8 to a width of 53 ft. at the springing. The arch is riveted throughout, and was exported from England. The deck is 30 ft. wide, and the bridge carries a single narrow gauge line of railway, from which a fine view of the Falls is obtained.

Paderno Bridge.—The wrought iron open web arch over the river Adda, at Paderno, was built in 1889, and is one of the longest and highest bridges in the world. The parabolic arch span is 492 ft. in length, and the deck of the bridge is 265 ft. above the water. The arch ribs are 16 ft. 6 in. apart at the crown, but are battered out in a plane of 1 in 6⅝ to a width of 56 ft. at the springing. Each of the two arch ribs is formed of double members 1 metre apart. The centre of the arch rib has a height of 123 ft., and the springings are rigidly fixed. The lattice girders carrying the deck are 16 ft. apart, and 20 ft. 6 in. deep, and support two roadways, the lower one being for a single line of railways, and the upper one for highway traffic, 5 m. wide, and for pedestrian traffic two footpaths, one on each side of the viaduct, 1 m. wide. This is claimed to be the largest iron bridge in Italy.

The Lake Street Arch Bridge, across the Mississippi, at Minneapolis, was erected about 1888, and is said to be the largest three-hinge arch in America. The two ribs in each span are spandril braced three-hinged arches built in vertical planes on timber centering, which was erected on the ice during the winter season. The large spans are each 456 ft. in length. The diagonals are pin-connected, while the other members are riveted. The two spans are disconnected, as shown in the figure, from each other, and from the adjoining framework, thus preventing cantilever action.

As originally built, the roadway was only 18 ft. wide, but it was widened in 1905 to a width of 33 ft. to carry two lines of electric cars, and at the same time an additional arch rib was erected in each span midway between the two old arch ribs, the position of which was not altered.

Oakland Bridge.—The fine arch at Pittsburgh, known as the Oakland bridge, was built in 1907, across the Pittsburgh junction railway lines and a ravine. The arch ribs have a span of 440 ft., and are curved lattice girders without hinges, 10 ft. deep in the centre, widening out to 14 ft. at the springings. At each end of this span are several smaller spans of 30 ft. and 40 ft. The bridge carries a roadway and footpaths.

Hell Gate Bridge.—The largest arch span in the world is that recently built over Hell Gate in New York City, with a span of 977 ft. 6 in., and a total height of 305 ft. above mean high water. The rise of the intrados of the arch is 220 ft.

The criticism has been made that the greater depth of the trusses at the ends was adopted solely for the sake of appearance, and that much metal and money could have been saved by making the arch of a crescent form.

The ribs are of the two-hinged braced rib type.

High carbon steel was used because of the high prices asked at the time for other alloy steels. Many of the rivets are of large size, being 1¼ in. diameter and 10 in. grip.

The width of the bridge is 60 ft. centre to centre of trusses and 90 ft. between the railings on the outside. The height of 135 ft. clear was prescribed by the War Department to be preserved for a width of 700 ft. The panel points of the bottom chord lie on a parabola. Four lines of railway are carried on a heavy ballasted floor, and two footpaths are provided outside these, one on each side of the main arch ribs.

The river conditions excluded the use of falsework in the water except for a very short distance from each abutment. The remainder of the erection was therefore carried out on the cantilever principle with the use of temporary back stays.

The heaviest pieces which were lifted as units had a weight of 180 tons. Powerful hydraulic jacks of 3000 tons capacity were used for the adjustment of the arch, the plungers having a diameter of 39 in. and maximum stroke of 26 in. The erection of the arch was commenced in January, 1915, and the arch was closed in October of the same year.

[TO BE CONTINUED]

Ancient Cart-Ruts in Malta

CAPT. E. G. FENTON discusses in the May issue of *Man* the remarkable cart-ruts found in Malta. It has been formerly assumed that they date from prehistoric times, and that they probably belong to the Neolithic period. There is no sign of a groove cut by horses' feet between the ruts, and the suggestion has been made that they are the result of human power in the shape of a number of men drawing wagons, and that the Neolithic civilization was brought to a close by a period of desiccation, such as that discussed by Ellsworth Huntingdon in "The Pulse of Asia," the dawn of our Mediterranean historical period being heralded by the increase of moisture. Capt. Fenton, on the whole, believes that they date from the early part of the Iron age, at a time when the Mediterranean was moister and the island was capable of supporting a larger population than under present conditions. The suggestion that these climatic changes can be equated with events in Egyptian history is interesting, but the evidence is scarcely sufficient to support any definite conclusion. Prof. Boyd Dawkins, in the June issue of *Man*, asserts that the ruts are "due to the weathering of the rock under vaporal conditions. They are merely the ordinary joints, widened and eroded by the rainwater containing carbon dioxide, familiar to geologists in all limestone plateaux, and to be seen over very wide regions in Southern France."—*Nature.*

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